INTERAVIA

REVIEW OF WORLD AVIATION

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Pocket-Size Combat Aircraft

VOLUME X 3 1955

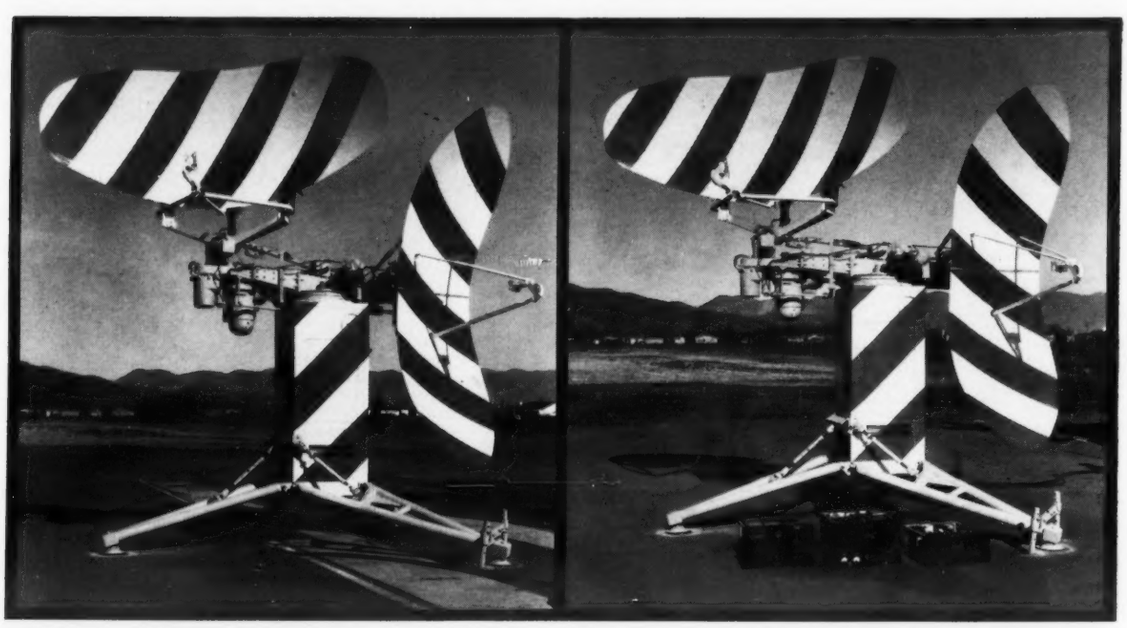
New higher power GCA **QUADRADAR** unveiled by Gilfillan

Two Models Now Meet Complete Range of Air Traffic Problems

Over two hundred international aviation visitors to the successful demonstrations of the 50 kw. GCA Quadradar during November and December 1954 in Los Angeles were also shown a completely new higher power 200 kw. Quadradar.

The 50 kw. Quadradar in field demonstrations and during the U.S. Air Force and U.S. Army operational evaluation tests now under completion exceeded both military and civil airport requirements. Now the 200 kw. Quadradar provides even greater performance capabilities with 40% increased range and altitude coverage over the 50 kw. equipment.

Both the 50 kw. and the 200 kw. Quadradar have complete remoting controls and instant multiple runway coverage.



50 kw. Quadradar operated perfectly during several recent California rainstorms. Successfully tracked F-86 jet fighters beyond 30 miles and above 20,000 ft. Both 50 kw. and 200 kw. models (at right) include proven circular polarization to eliminate rain and snow clutter.

GCA RADAR AND ELECTRONICS
Gilfillan
LOS ANGELES
GCA
AROUND THE WORLD

200 kw. Quadradar provides 40% additional coverage in range and altitude. Both models are identical except for three small components — transmitter, receiver and high voltage power supply — as shown. These 3 components quickly plug in to replace the 50 kw. components.

INTERAVIA

Review of World Aviation

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Light-weight combat aircraft a reality: the Douglas A4D Skyhawk strike aircraft, several of which are flying. On the ladder: Ed. Heinemann, designer of the type (cf. article in this issue).

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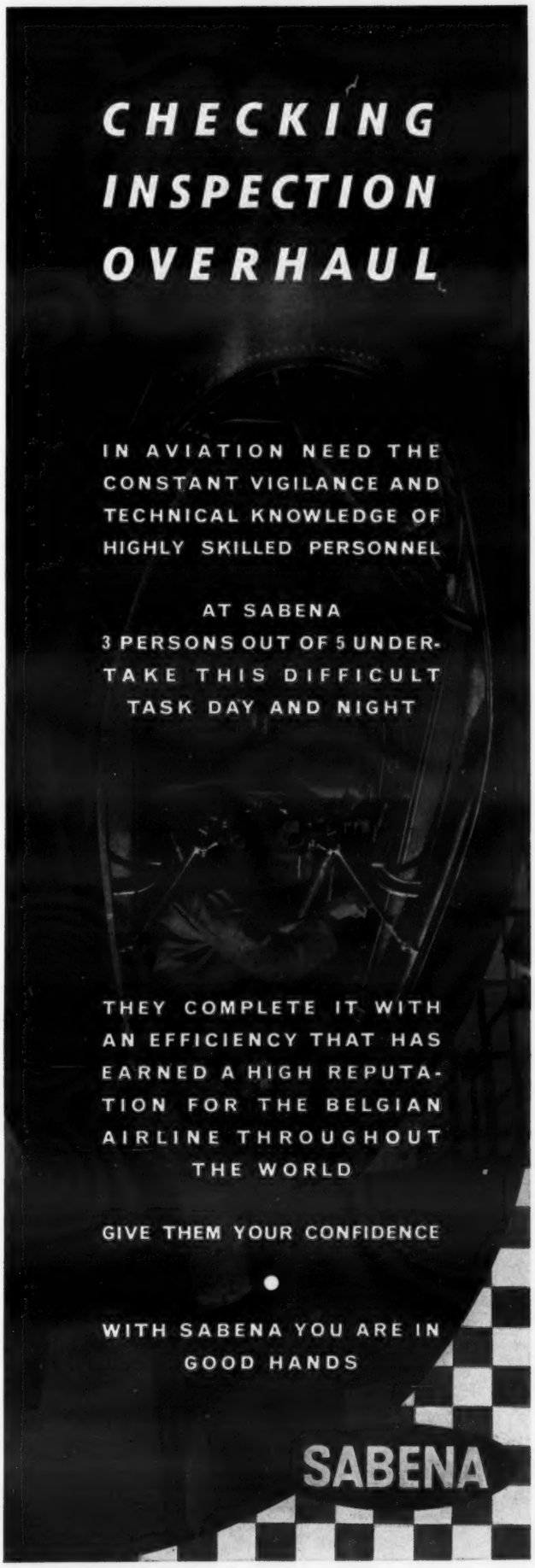
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AVIATION

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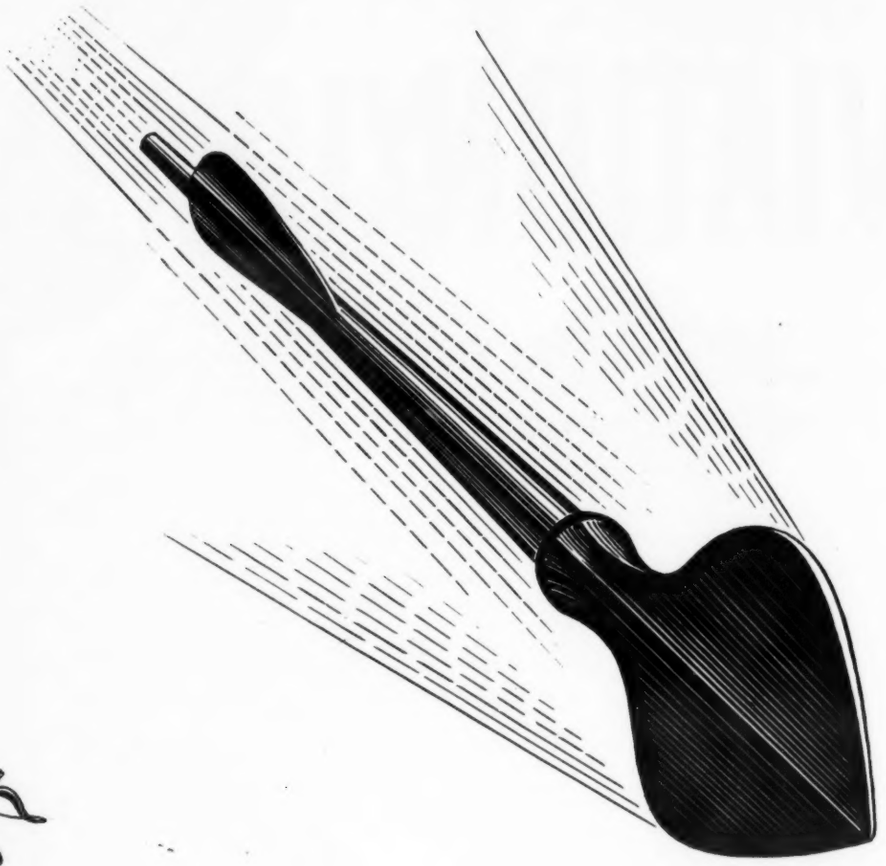

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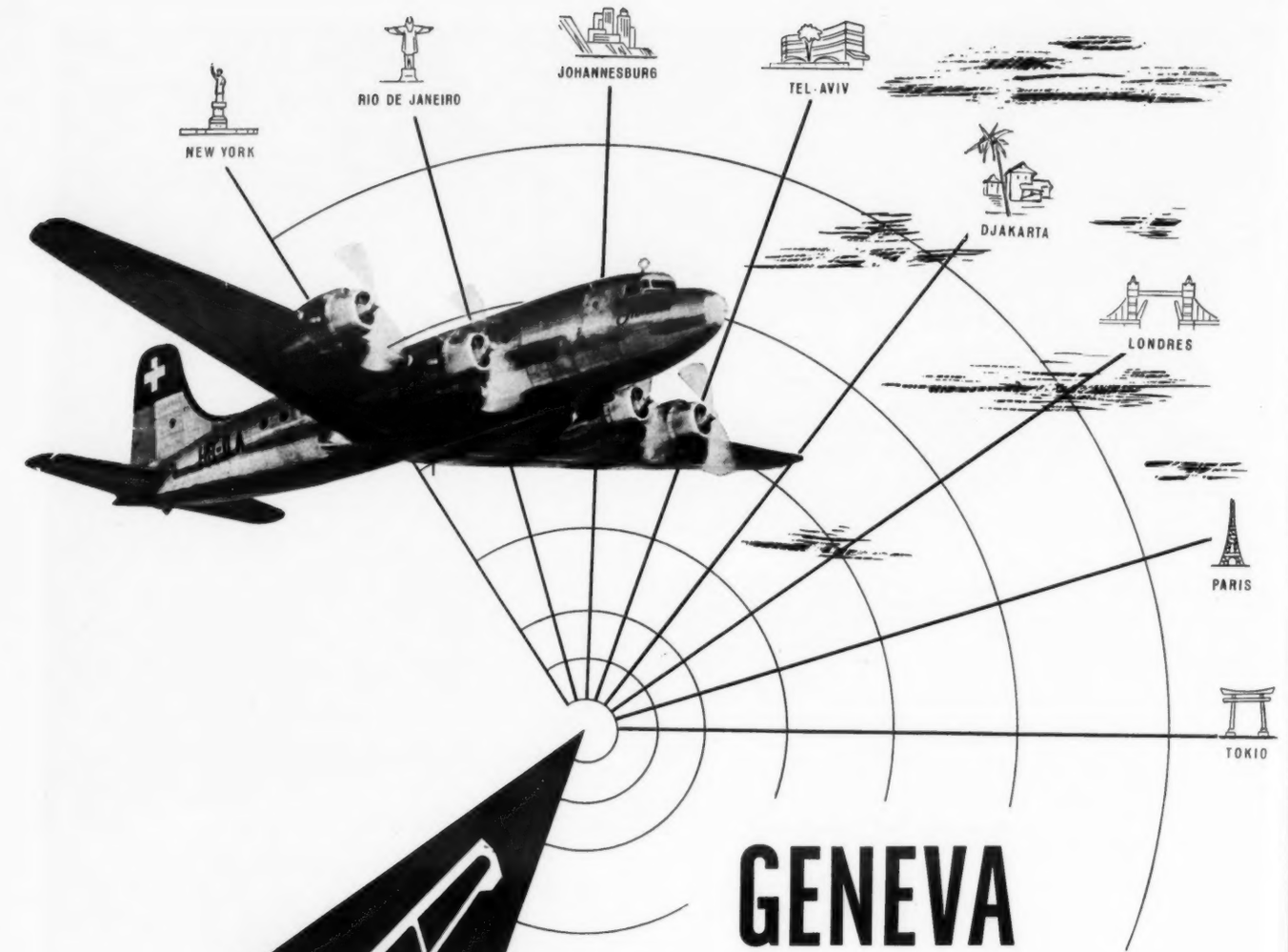

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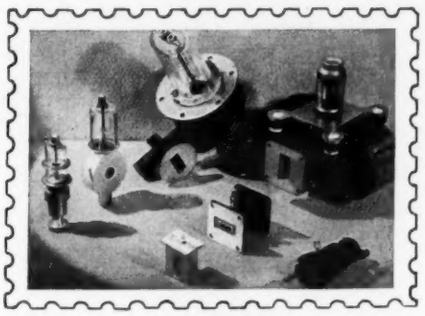

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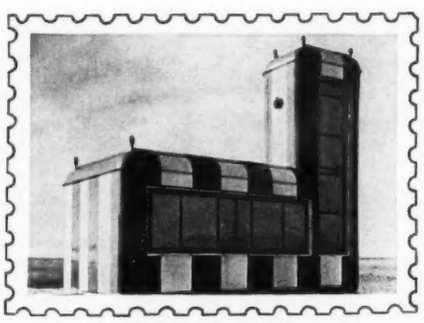

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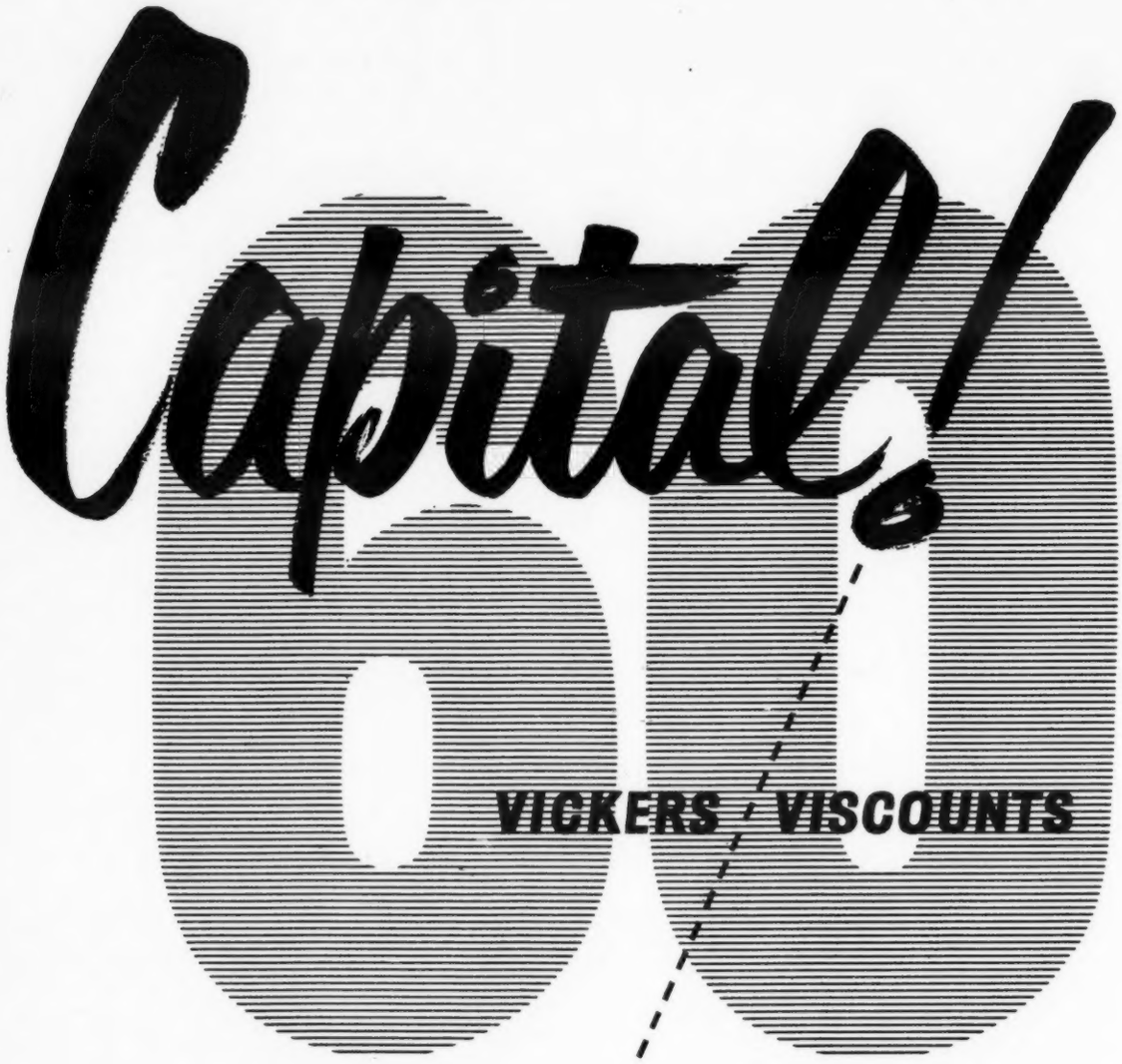

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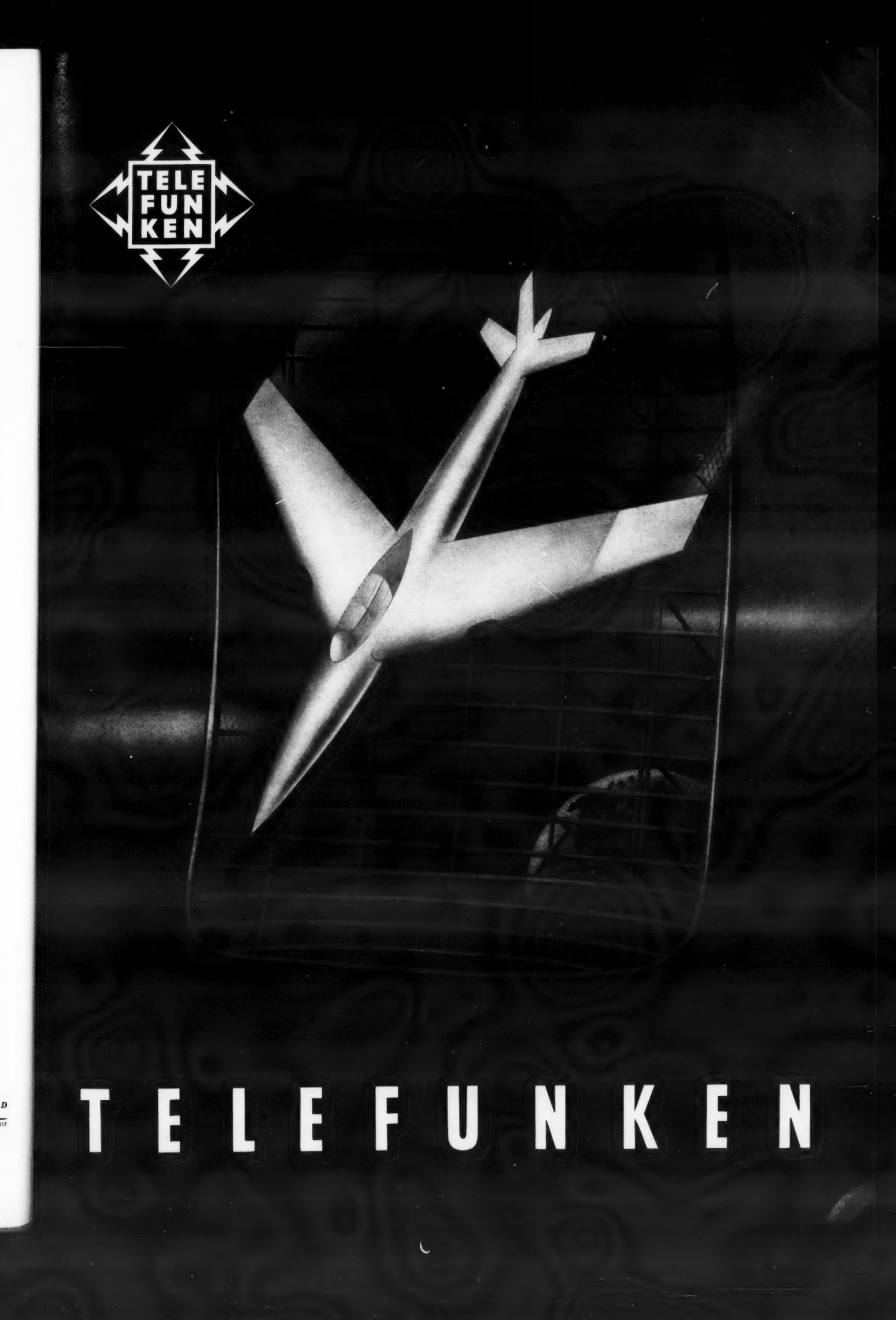
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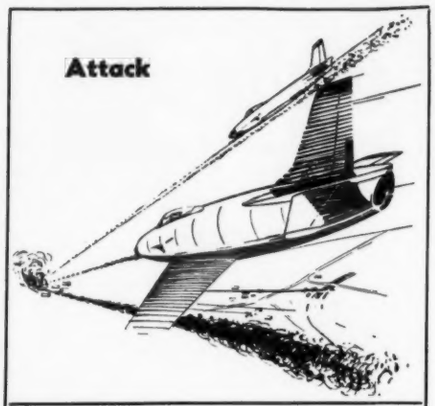

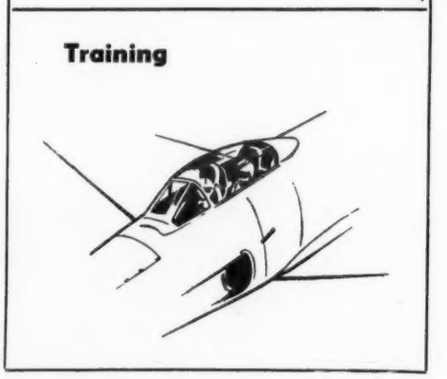

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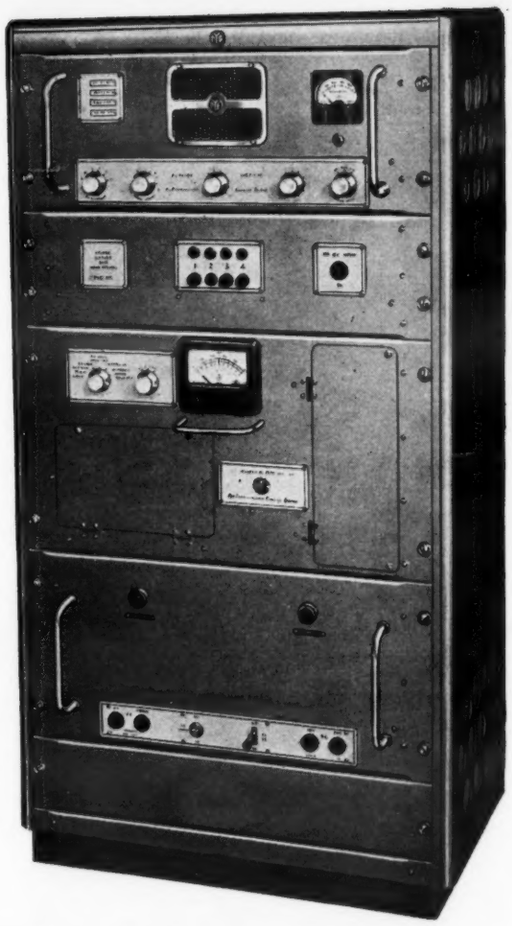

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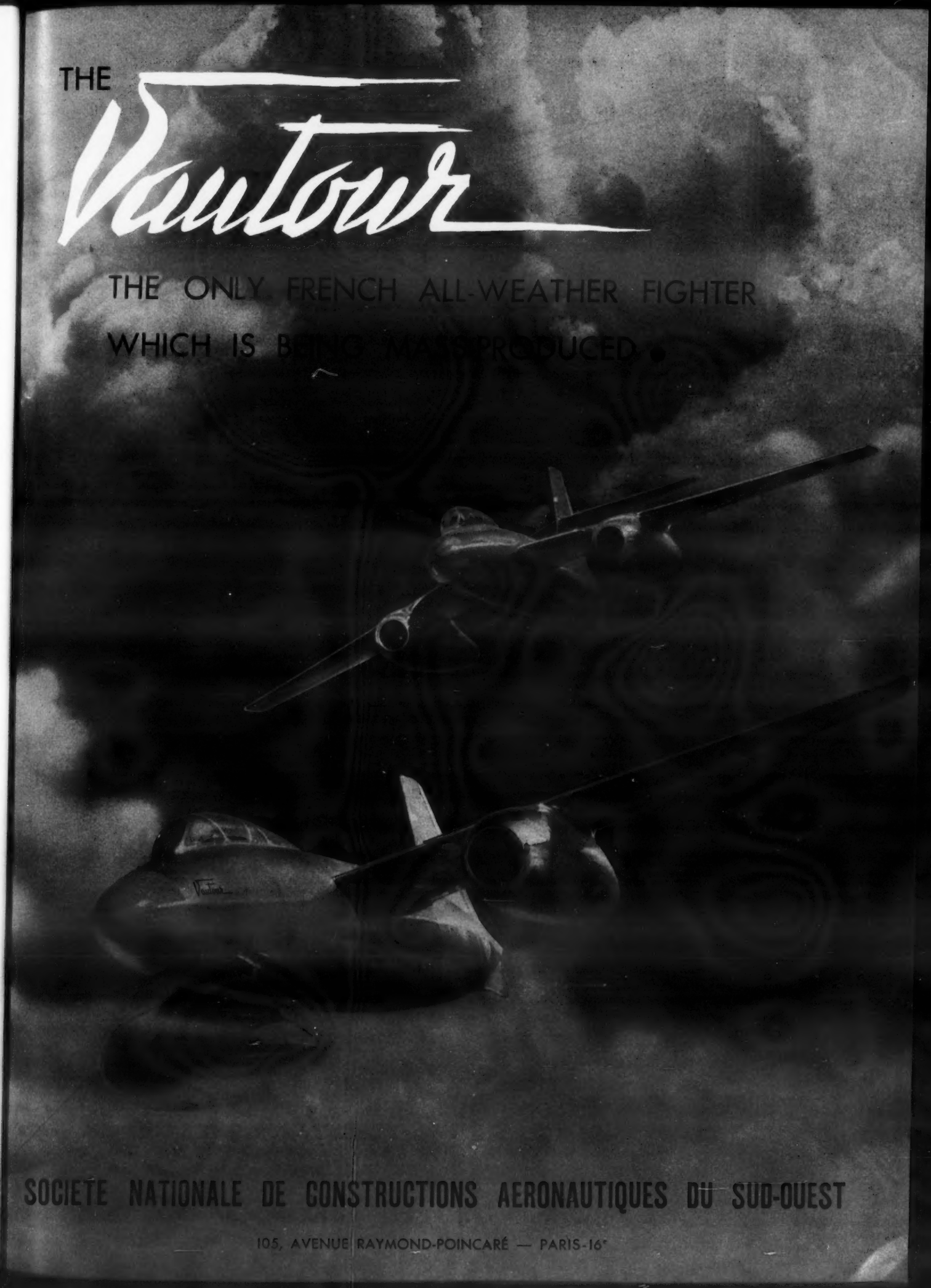
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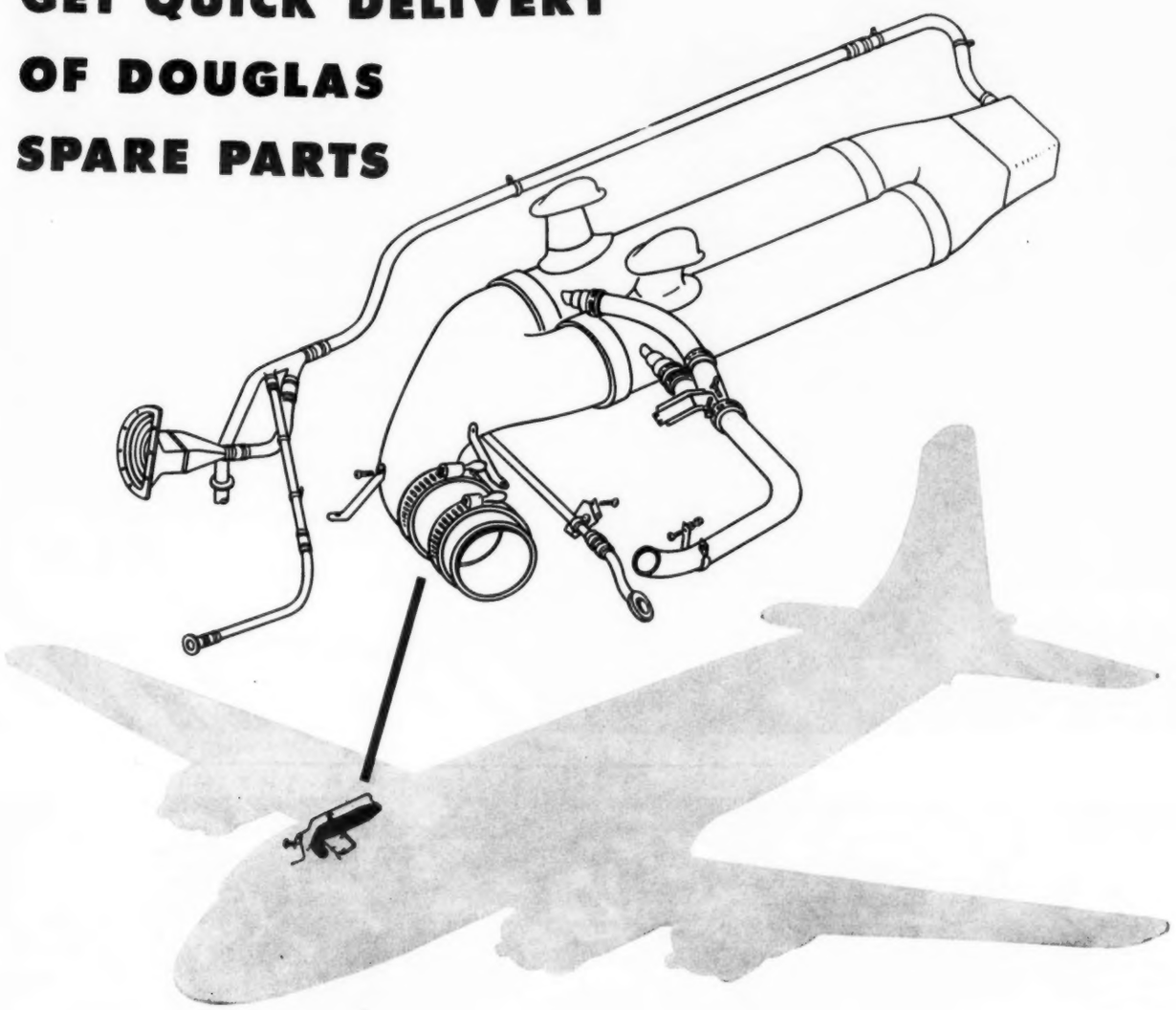

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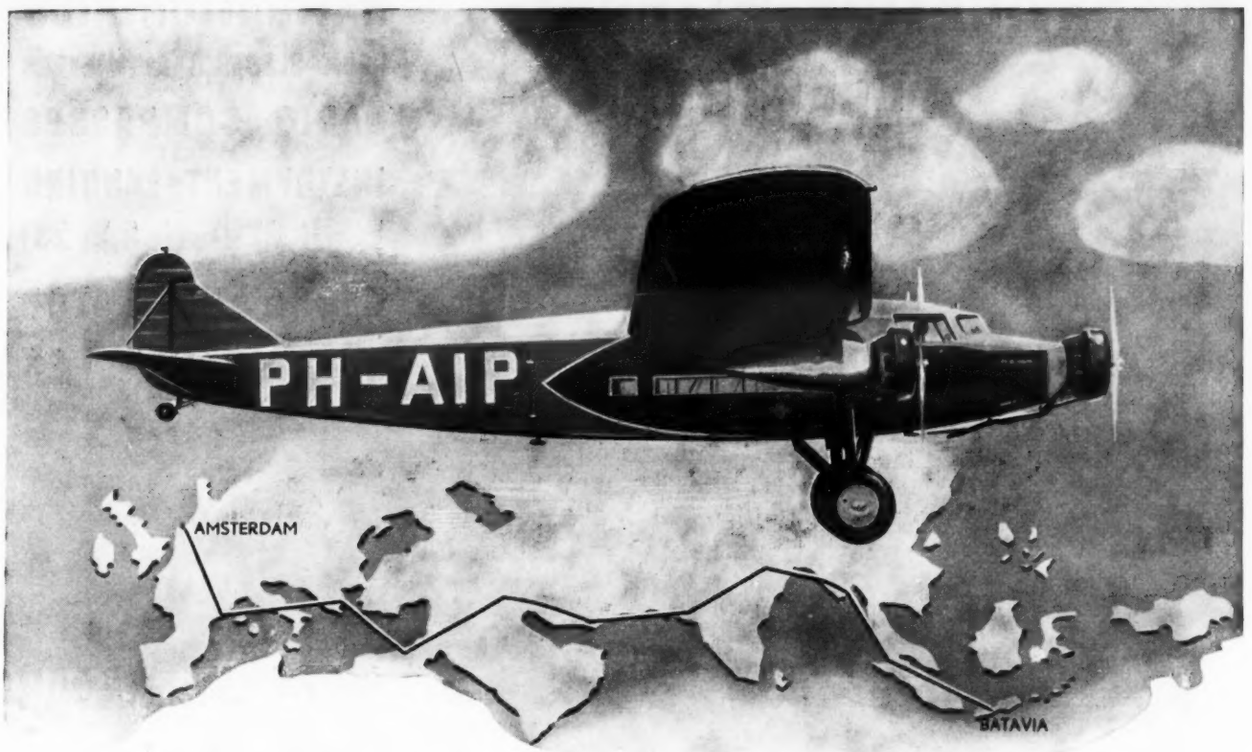

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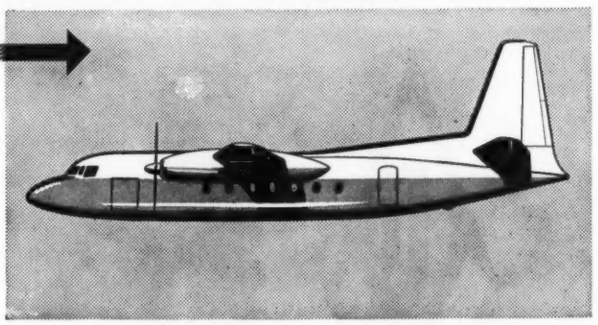

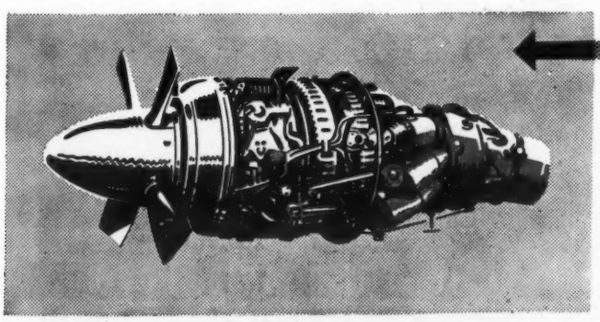

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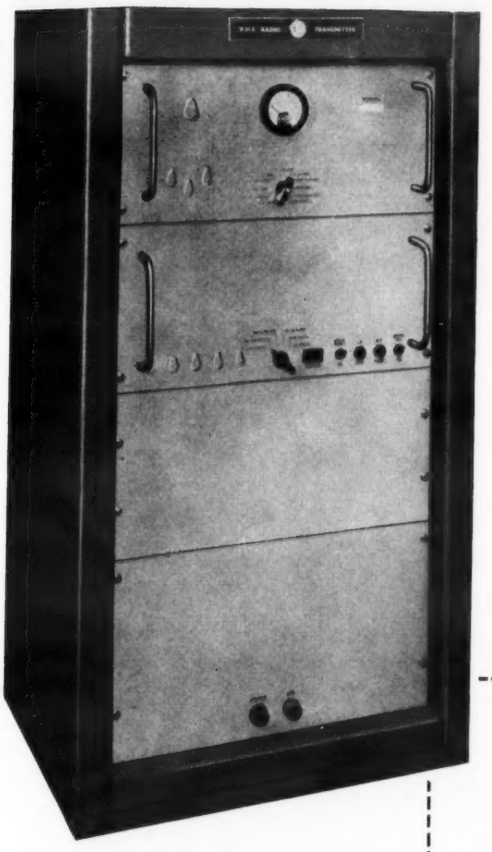
Ground to air operation by VHF airfield communication equipment



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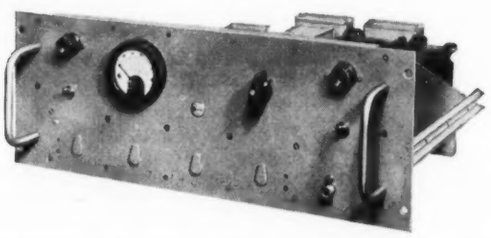

Shown above is the type AD 801 transmitter. It is compact and sturdy and, when fitted with shock absorbers, suitable for mounting in a vehicle. On the right is the type AD 818 receiver designed for aerodrome use in association with the AD 801 transmitter.

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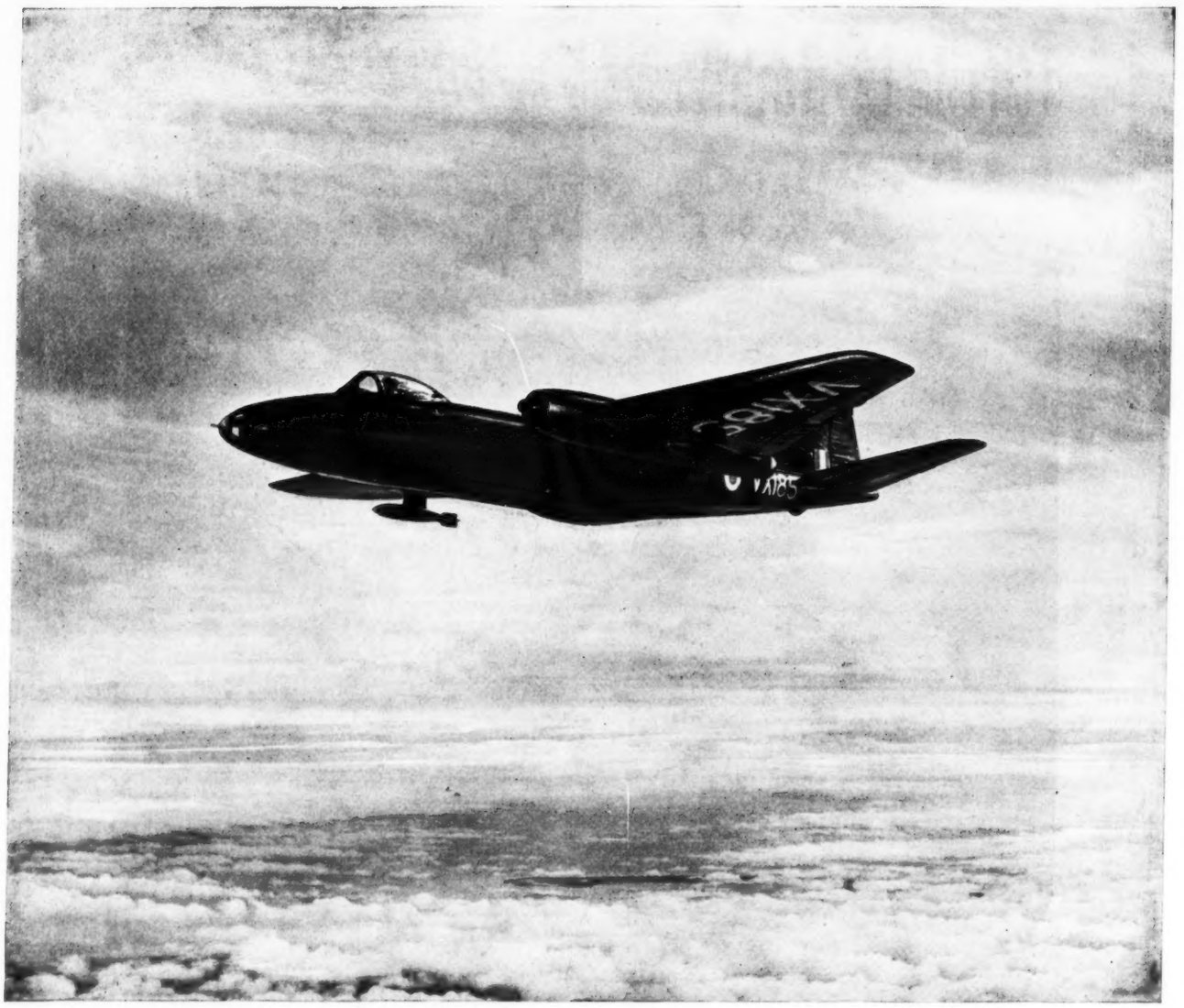
LA 8



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The Canberra B 8 is the most versatile of the Canberra series. It can readily be converted to perform a number of rôles, including night intrusion, high altitude bombing and target marking. In its Night Intruder rôle it carries underwing armament and forward-firing cannon in the bomb bay. The offset fighter-type canopy gives the pilot a superb all-round view and the re-designed navigator's compartment provides better vision and a wider range of navigational aids.

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INTERAVIA

Deadline Notes

No. 3, 1955.

WHITE PAPER ON BRITISH AIR ARMAMENTS

The British Government has replied to recent criticisms of delays and confusion in aircraft procurement with a White Paper which states that "this country has an effective air defence against what any potential enemy is at present able to bring against us." The Government, however, plans to move towards the treatment of aircraft as an integrated "weapons system", on the lines introduced in America, i.e., in which complete responsibility for coordinating airframe, engine, armament, radio and navigational equipment etc. rests with the designer of the aircraft.

SWEDISH AIR FORCE VOTES FOR LANSEN

The Royal Swedish Air Force has asked for 81,000,000 crowns for procurement of the Saab-32 Lansen two-seat all-weather ground attack aircraft, in place of a repeat order for Hawker Hunters. The reason is said to be not the technical difficulties experienced by the latter fighter but the fact that the 120 to 140 Hunters previously ordered cost considerably more than originally estimated by the manufacturers.

RADIO-ACTIVE "FALL-OUT" FROM HYDROGEN BOMBS

According to an Atomic Energy Commission report the lives of unprotected persons living in an area 140 miles by 20 miles would be seriously endangered by radio-active "fall-out" from a thermonuclear bomb such as that exploded at Bikini in 1954. Furthermore, 50% of the people 160 miles downwind from the explosion might die, and over 5% of those 190 miles away. - This is the first official statement assessing the dangers of radio-active "fall-out" and has been followed by the announcement that a Senate armed services sub-committee will investigate the whole problem.

AUSTRALIA SAYS NO TO H-BOMB TESTS

The Australian Government "will not allow any hydrogen bomb tests or experiments connected with them to take place in Australia", states Minister for Supply H. O. Beale, commenting on a statement attributed to a British Atomic Energy Authority spokesman that experiments "useful in developing the hydrogen bomb might take place in Australia."

MALAYA AS AIR BASE

The British authorities in Malaya have undertaken the reconstruction of three air bases (Pohang-Kuantan, Alor Star, Gong Kedah), which are to be ready for use by November 1955. Malaya will then have at least eight bases suitable for jet aircraft, three of them on Singapore Island.

SYDNEY-AMSTERDAM VIA ARCTIC

Canadian Pacific Air Lines will operate a through service between Sydney, Australia, and Amsterdam from June 7th, 1955, when its Sydney-Vancouver trans-Pacific service will be connected up with the Vancouver-Amsterdam trans-Arctic service it plans to open in May. - Total distance 12,500 miles; equipment Douglas DC-6Bs; flying time 49 hours; calls at Honolulu, Vancouver, Churchill, Manitoba, Soendre Stroemfjord (?).

U.S. AIRLINES TO FIT IDENTIFICATION RADAR

An Air Transport Association meeting attended by representatives of 31 scheduled airlines prepared a plan to introduce identification radar in commercial transports to enable military ground stations to identify such aircraft flying over America.

* From INTERAVIA's world-wide news service, including INTERAVIA AIR LETTER, the daily international aviation news digest. — No part may be reproduced without written permission.

TELEVISION ON U.S. COMMERCIAL AIRCRAFT

A new passenger attraction offered by U.S. airlines is expected to be television programmes on board. Tests now in progress are said to be satisfactory. One of the major carriers involved is said to be Eastern Air Lines.

EXPANSION OF VIENNA-SCHWECHAT AIRPORT

The Schwechat operating company "Flughafen Wien Betriebsgesellschaft" is organizing a design competition for the modernization of the airport. Three prizes of 50,000, 25,000 and 15,000 Austrian schillings are offered for the best designs and three further payments of 5,000 schillings each for the purchase of the actual plans. Closing date for submission of designs, May 2nd, 1955 at midday.

DEATH OF PROFESSOR DE LA PRADELLE

The well-known French air law expert Professor Albert Geouffre de la Pradelle has died in Paris.

U.S. TURBOJET POLICY BOARD

U.S. Defence Secretary Charles E. Wilson has appointed a three-man board to draw up long-range policy and plans for the development of turbojet engines. Chairman is Frank D. Newbury, Assistant Defence Secretary, and the two other members James H. Smith, Assistant Secretary of the U.S. Navy for Air, and Roger Lewis, Assistant Secretary of the U.S. Air Force. The Board expects to issue its first report by April 30th, 1955.

MAGISTER LICENCE FOR MESSERSCHMITT?

Negotiations are said to be in progress between Messerschmitt A.G., Augsburg, and Etablissements Fouga, Paris, on licence production of the Fouga CM.170 Magister jet trainer by Messerschmitt.

*

WORKSHOP BRIEFS ...

Britain's largest wind tunnel is being built at the National Aeronautical Establishment, near Bedford. The test section will be 8 ft. square, so that models spanning up to 6 ft. can be tested; max. speed of flow in the test section will be equivalent to Mach 2.7. Power required 80,000 h.p. * Fuselage made of glass fibre reinforced plastic would, according to Sir Arnold Hall, Director of the Royal Aircraft Establishment, Farnborough, probably be free from fatigue problems and cheaper to produce than present aluminium one; they should also be no heavier. * The French SFECMAS 1402 Gerfaut 1B experimental delta-wing fighter began flight testing in mid-February. Like the first Gerfaut prototype, the 1B reaches supersonic speed in level flight (without afterburning). * Etablissements Fouga & Cie. is tooling up for production of the CM. 170-R Magister jet trainer at the rate of 15 a month. First production models are to be delivered to the French Air Force in July 1955. * Lear Inc., of Santa Monica, California, is producing the L-10 autopilot for supersonic aircraft, which is expected to be fitted in a number of U.S. Air Force aircraft. Automatic Mach number control, automatic "G" control, all-attitude manoeuvrability, automatic heading selection, command manoeuvring by control stick as well as conventional controller, continuous side-slip control and continuous automatic trim control for all control surfaces. * It is known definitely that the Conway by-pass engine has two compressors. * Avro Aircraft CF-100 Mark IV and CF-105, both armed with air-to-air guided missiles, are expected to have the new Hughes Aircraft Co. E-9 fire control equipment. * A silencer for light aircraft is being tested by Société des Avions Paul Aubert: noise reduced by more than 60%; power loss about 1%; speed loss about 2 km/h. * Turbojets of the 2,200 lbs. thrust class are under development, it is rumoured, by three French engine manufacturers: SNECMA (R.105); Hispano Suiza (R.800) and Turbomeca (Gabizo).

* * *

From Short-Life to Pocket-Size Aircraft

The situation has been fairly clear for some three years.

Three years ago the newly-appointed British Under-Secretary of State for Air, G. R. Ward, described the difficulties encountered in the expansion of the Royal Air Force. He stressed the importance of reducing the complexity of modern aircraft as regards production and maintenance and added that the Air Ministry was investigating means of radically simplifying certain types of fighters. That was in the spring of 1952. *

It almost looks as if the investigators had worked with delayed action fuses. Otherwise they would not have involved their Under-Secretary in the undeserved embarrassments which he has had to face in the House of Commons since last December. His critics have been trying to make him responsible for the difficulties encountered in certain British aircraft, the programme for which was laid down before he took office and is still being laboured at. Other Members wanted to know why the old programme is not being scrapped and why much simpler and more economical aircraft designs have not been adopted, such as the Folland *Gnat* light-weight fighter now under development.

This situation is by no means restricted to Britain. It concerns the West's entire air defence. One of the British fighters under fire is being built in Holland and Belgium and is also to be supplied to Denmark and Sweden. And the whole subject has meanwhile become so to speak "supranational", since N.A.T.O. prepared a programme for light-weight combat aircraft in 1954.

*

The situation is clear enough, but in no way new.

It was obvious three years ago that something had to be done. It may be recalled that in *Interavia's* July 1952 issue the subject was discussed under the heading of "Short-Life Aircraft", by international writers: ... Must a combat aircraft cost millions a year ...? The actual operating force of aircraft is supported by a grotesque administrative and maintenance colossus out of all proportion to the results achieved... In the present state of engineering a fighter aircraft with an operational life of 100 flying hours probably requires no less than 100,000 man-hours. In other words each hour of its flying life necessitates 1,000 man-hours of labour ...

The same issue recalled the de-refined aircraft—Lippisch Me 163, Heinkel He 162 "People's Fighter" and Bachem BP 20 *Natter*—which Germany developed in her desperate situation towards the end of the war. The value of these projects was simply overlooked in the German defeat. At the end of the war Allied staffs just could not imagine that they would ever be faced with the problems which the German command had to meet shortly before the collapse.—Today these problems are universal.

*

The stripped combat aircraft outlined here at that time was termed a "short-life aircraft", which was probably a terminological error. All war material is of limited life, because of wear and tear, obsolescence, accident or enemy action. However, if an aircraft is described from the outset as "short-life" it is devalued even before it gets into operation, i. e., it suffers a psychological denigration in the eyes of those who are to buy, maintain or fly it.

Though the said terminological error has no effect on actual development, it has been corrected in the present issue. Following the example of the German "pocket cruisers" of the 'thirties', we now propose the term "pocket aircraft", or "pocket combat aircraft". Such light-weight combat aircraft are bound to come. Both technical and economic resources have been overstretched; simplification is inevitable.

*

Projects for light-weight or pocket aircraft have been prepared in Britain, France, Italy and the United States. Even the Japanese seem to be doing something along these lines. And Russian designs have long been flying.

Once again the subject is discussed in some detail in the following pages, in the hope of making a modest contribution to a speed-up in this inevitable development.

*

Is it surprising that the United States—the only country that could afford "luxury super aircraft"—should be the first air power in the West to bring out two operational light-weight aircraft? The Americans are always logical in their technical and no less so in their economic, thinking. Not much more than the type designation of one aircraft is known, but certain details are available of the other. What may officially be known of it the reader will learn first hand, from E. H. Heinemann, Chief Engineer of Douglas Aircraft Corp.'s El Segundo Division, designer of the A4D *Skyhawk,* who describes in this issue the principles on which he based his design.

Interavia regards it as a pleasure to publish an article by Ed. Heinemann. More than three years ago we sat with him on the shores of Lake Geneva, talking of everything under the sun—except aviation. It was his first day in Switzerland, and he admitted that it was scandalous that he had never been here before. His mother had been Swiss. We asked him how he had spent his first morning in Switzerland. It was a cool autumn morning, but he, around 45 at the time, had spent an hour water-skiing, then made a tour of the town and bought his daughter a cuckoo clock. A congenial man, with no attempt to put on airs. But those who know him better know what he has in him.

*

The pocket aircraft is thus an accomplished fact. Its design problems have been solved, and those of its electronic and other equipment are on the way towards solution.

The only strange fact is that once again the "motorist" is keeping the others waiting. True, a light medium-powered turbojet has been developed during the past few years in Britain, but it is not yet in production. Plans are being made, too, by three French engine manufacturers to make up for lost time, and it will surely not be long before American manufacturers realise the value of this line of development. Then the pocket combat aircraft will really become everyday equipment for the air forces. And then military staffs will begin to wonder ... why they did not think of such a solution earlier. Despite its apparent initial technical complications, it has turned out to be quite simple in the end.

* cf. *Interavia*, No. 7, 1952, p. 365.

Pocket-Size Combat Aircraft

One Idea, One Programme: Four Countries

Light-weight combat aircraft needed for both offense and defence

BY INTERAVIA STUDY GROUP

First conceived by the Third Reich at bay, the modern light combat aircraft's merits were later recognized by a small number of specialists, then adopted by leading engineers. For a long time, however, it was disdained by the military staffs. Yet it may be that tomorrow it will be equipping a good number of squadrons.

Though originally prejudiced by the German defeat, the resurgence of interest it has recently provoked is due to a number of reasons, among which the first is the most decisive, namely the small size and weight of the atomic projectile. Then there are the increasing specialization of air equipment, the revolutionary nature of atomic warfare, the reaction of users against the growing complexity of the aircraft supplied to them, and, behind these technical, operational and psycho-physiological motives, a no less decisive factor: the money barrier.

When the U. S. Air Force announced that the F-84 fighter-bomber could carry an atomic projectile, the technical and operational border which had always separated bombers from fighters was suddenly eliminated. But when photographs were published of the 28-cm cannon, showing the size of the shells it fires, it was seen that the actual explosive had become a negligible quantity as regards weight and volume. All that had to be allowed for in deciding the weight of the carrier aircraft was the fuel to give it range and the navigation and sighting equipment needed to ensure all-weather operation. It is naturally the medium and low-weight aircraft which benefit from this considerable reduction in the burdens imposed by the explosive projectiles of old. Though the saving in weight in the B-36 and B-47 is only 3% and 5% respectively of the total atomic tonnage, the World War II *Lancaster* could have been lightened by 10% or have increased its endurance by the amount of extra fuel it could have carried. In the Republic F-84 the weight of conventional armament may reach 25% of the aircraft's gross weight. The atomic projectile weighs less than the fixed armament in a fighter like the Hawker *Hunter*. But it has a greater destructive power than 2,000 tons of TNT bombs, dropped by five hundred 1945-style bombers, or than the 100,000 HVAR 5-inch rockets which could be fired by some 3,000 F-84s.

Such is the "striking power" of the Douglas A4D *Skyhawk*. Chief Engineer E. H. Heinemann had three trump cards to play with: the negligible weight and volume of a nevertheless all-powerful weapon, the low specific consumption of the Wright J-65 (Armstrong Siddeley) *Sapphire* turbojet, the simplification and miniaturization of the components needed for his machine. With a gross weight of approx. 15,000 lbs., the *Skyhawk* is said to have a greater endurance than the piston-engined Douglas *Skyraider* (more than 1,500 miles). Weighing only one eighth as much as the B-29 *Superfortress,* the new miniature bomber would fly less than half as far as the four-engined Boeing but would carry a bomb whose destructive effect would equal that of a formation of at least 500 B-29s. Admittedly the *Skyhawk's* sighting and firing platform and its equipment for navigation in bad weather may render it less independent of the weather than its piston-engined forerunner. However, Heinemann has stated that he has been able to incorporate all necessary electronic equipment in his last-born. Moreover, in view of the destructive range of the A-bomb, greater tolerance can be permitted in aim. Thus the rapid development of explosives tends to divide offensive combat aircraft into two classes: those with long range, which, being necessarily designed around the weight

New light-weight offensive aircraft for the U.S. Navy: in the foreground the Douglas A4D *Skyhawk* (medium range), in the rear the twin-jet Douglas A3D *Skywarrior* (long range).

Emergency take-off method for atomic warfare: to enable combat units to take off direct from decentralized points in the event of the runways being destroyed, the U.S. Air Force has tested an emergency take-off system with very high-power take-off rockets. Take-off is from a Glenn L. Martin launching rig such as was developed for the B-61 *Matador* pilotless bomber. A Republic F-84G *Thunderjet*, complete with pilot, being hurled into the air. A runway remains essential, however, for landing.

of fuel they must carry, will be relatively heavy; and those which, designed to attack targets at shorter range, can be limited in weight and size. One item remains constant in both categories, the weight and bulk of the electronic equipment needed for the accomplishment of their respective missions. Even here the burden can be lightened by the use of pathfinder aircraft, as during World War II, or reduced progressively through advances in electronic engineering.

Air cruiser or target-defence interceptor

The crushing power now wielded by a single aircraft has given new impetus to the techniques of defence. What was the classic fighter up to yesterday was the result of a compromise between performances requiring contradictory characteristics. The tendency now is to replace it with more specialized equipment. The defence arsenal may in future include several different aircraft types. In order to get the utmost out of technical developments, compromises must be avoided. Defence of the air space can thus best be ensured by using a number of different machines, each the best possible for its particular duties. A heavy aircraft, for example, would be used for long-range defence. Though it might have a relatively low rate of climb, it could cruise for a long time and engage the enemy a long way from his targets. At the other end of the technical scale, the light aircraft would defend vital areas or targets in the advanced fighting zone. It would come somewhere between the piloted fighter and the static defence missile. This is the definition to which the design and execution of the Lockheed F-104 would seem to correspond. All that is known about this aircraft is that it has supersonic speed and is said to reach a ceiling of about 60,000 ft. In announcing its first tests a year ago, the U.S. Air Force stated that the XF-104 was designed to obtain local air supremacy in a limited air space, which it would sweep clear of the enemy. Like the Douglas light offensive aircraft, Lockheed's latest creation weighs around 15,000 to 18,000 lbs., or

New defensive aircraft: the SO. 9000 *Trident*, prototype of a French light-weight fighter designed by S.N.C.A. du Sud-Ouest.

The Douglas A4D-1 *Skyhawk* in flight, with streamlined bomb (tactical A-bomb ?) suspended beneath the fuselage.

roughly half as much as the Convair F-102. Like Douglas's engineers in the *Skyhawk*, Lockheed's are also said to have succeeded in housing in its fuselage the equipment needed for operation in all weather conditions. In Europe, S.N.C.A. du Sud-Ouest with its *Trident* — which combines jet and rocket power—and Folland with its *Gnat* have been following the same path. *This class of defensive equipment is of even greater value in Europe since warning periods are shorter and defence budgets more limited.*

The air fighting in Korea provided the advocates of lighter aircraft with fresh arguments. Despite the success of the F-86 in battles against the MiG-15, many American pilots began to demand simplification of the aircraft entrusted to them. The race for improved performance began to necessitate the elimination of equipment not considered to be essential to the actual fighting. There were those who, forgetting that the *Sabre* has almost double the endurance of the MiG-15, considered the F-86 to be nearly two tons too heavy. Having to use aircraft designed for a different purpose, under conditions favourable to the enemy, Korean veterans demanded better performance in the way of rate of climb and ceiling. Colonel Francis Gabreski became the champion of weight reduction and simplification, and was supported on the engineering side by C. "Kelly" Johnson of Lockheed and Ed. Heinemann of Douglas. Unnecessary armour, excessive safety devices, bulky equipment that could be miniaturized, armament designed for an operational life well in excess of the aircraft's life, all these were points that could be simplified so as to obtain a weight saving.

The ordeal by fire thus created the climate needed for this revolution in production methods and even in the basic concept of certain categories of aircraft. *The United States, Britain, France and without a doubt Russia have set some of their engineers working on light-weight configurations.*

Concrete a thing of the past

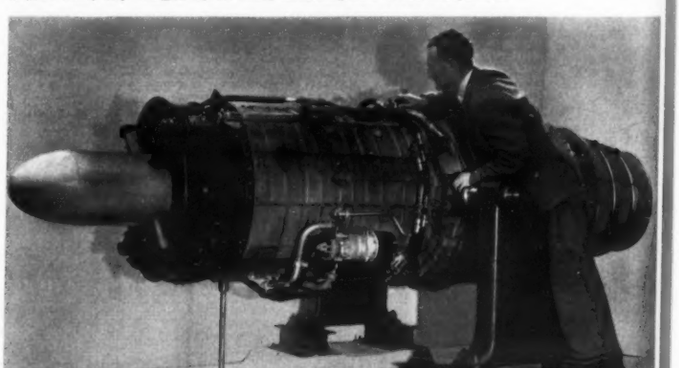
Whether for localized conflicts such as Korea, or for a generalized atomic war, military staffs are demanding the abolition of the long concrete runways essential for heavy aircraft. Defining the fighter with ideal performance at the time, the pilots of the 4th and 51st Interceptor Wings fixed its weight at around 10,000 lbs., its speed at a little over Mach 1 and its operating ceiling at about 50,000 ft. But they also demanded that it should be able to operate from short—and if possible rudimentary—runways as close as possible to the front line. In atomic warfare the concrete process is no longer feasible. Its vulnerability and cost, the lack of mobility it imposes on the air units using it, all relegate it to the past in the history of air strategy.

To meet the special needs of European defence *N.A.T.O. has worked out a programme for light tactical aircraft,* based on the efforts being made everywhere to develop light-weight designs. Air support for the ground forces remains just as important in the atomic era. The greater the destructive power of atomic weapons, the more the opposing forces will seek to disperse their ground units and the more targets for conventional weapons they will thus create. The greater the speed at which ground forces can move, the more decisive will be the role of the ground attack aircraft, which alone will be capable, thanks to its speed, of intervening in time.

Four years ago thousands of F-84s were allocated to the continental countries, under the United States' programme of aid to Europe to strengthen its defences. Though formidable in

Fitting the Wright J-65 *Sapphire* turbojet in the Douglas A4D. The low fuel consumption of this engine contributed substantially to the miniaturization of the Douglas A4D *Skyhawk* and the Lockheed F-104A.

The British Armstrong Siddeley *Sapphire* engine, for which the American Curtiss-Wright corporation holds licence rights: static thrust of the AS.Sa 7 version approx. 10,200 lbs.; dry weight 2,972 lbs.; consumption 0.885 lbs./lbt. h.



Folland *Midge* experimental aircraft, predecessor of the light-weight *Gnat* fighter and ground attack aircraft.

the air, the F-84 is vulnerable on the ground because of the long runways needed for its heavy load and high-pressure tyres. As the European countries cannot remain dependent for ever on the United States for their ground attack aircraft and as these aircraft cannot make do without highly vulnerable ground installations, a new system has to be found.

Last March "Aviation Week" announced that a new programme had been drawn up for the design of ground attack aircraft which would be easier and less costly to build and could operate from ground bases less vulnerable than those required for the *Thunderjet* (cf. the following article).

This programme could be filled by the Folland *Gnat*, brought out two years in advance of other designs. Its designer, W. E. W. Petter, originally conceived it as an interceptor rather than a ground attack aircraft. The *Gnat* corresponds to the new concept of low-tonnage combat aircraft. As every pound of additional equipment entails an increase of ten pounds in gross weight, Petter set out to simplify his new machine to the utmost. By reducing its dimensions, he has been able to dispense with certain accessories and, for example, obtain great lateral manoeuvrability without servo controls. The Folland stand at Farnborough last year showed an interesting comparison between the accessories which had been offered the designer at the beginning of his work and those which he had finally obtained through insisting on miniaturization. *It is not only the* Gnat *which has benefited from this battle against weight, bulk and production costs. Tomorrow it will bring advantages to the whole of aeronautical engineering.*

The military and technical authorities in the United Kingdom did not immediately accept the Folland experiment. They do not believe in miracles in this field and consider that if Vickers and Hawker arrived at the weight of the *Swift* and *Hunter* and North American at that of the F-100 it was because authentic technical and operational requirements obliged them to. The demonstration flights by the Folland *Midge* at Farnborough probably did not change the point of view of the experts across the Channel. But they certainly helped to prove the value of the *Gnat* concept. The *Gnat* also has the advantage that it is flying and is a concrete example of a new concept not yet universally accepted.

A. V. Roe have also entered the lists, but their projects are a great deal more secret than Folland's. The champions of the delta wing have proposed a derivative of the Avro 707, a delta version of the light aircraft, based on the firm's experience of high-speed aerodynamics. On the Continent, S.N.C.A. du Sud-Est has submitted the *Baroudeur*. This aircraft meets the programme as regards simplified ground installations, but exceeds the gross weight limitation, since it weighs more than the stipulated 10,000 lbs. on take-off. Marcel Dassault has also designed a new aircraft, the *Mystère 26*, which is probably a scaled-down version of the *Mystère*. Bréguet, too, has submitted an attractive design in the *Taon*. Italy's engineers have set out to attack the vast market open to a replacement for the F-84. There has been talk of a special version of the *Sagittario* and of a design by Gabrielli using the experience obtained with the Fiat G. 82 trainers.

Three projects around one turbojet

In the execution of the programme, power plant and equipment are more important than aerodynamics. Accessories manufacturers are quite capable of reducing the weight and volume of their products if the users are not too demanding. Both sides must accept a new philosophy, which harmonizes the required operational efficiency and the limitations of the essential equipment. As regards power plant, an entirely new concept had to be developed. Ever since jet engines have been made—or any kind of engines for that matter—the power curve has gone on rising and the drive towards greater power continued. The new aircraft emerging from the N.A.T.O. contest will not be able to use engines with 8,000 lbs. of thrust, designed for airframes weighing 14,000 to 20,000 lbs. The engine manufacturer has had to make an effort of technical imagination and, drawing the utmost profit from experience gained during recent years and from the new structural materials and new techniques that have been perfected since the *Derwent*, J-35 and *Nene*, to design an engine with a thrust of 4,000 to 5,500 lbs., lighter, less bulky and, if possible, with a lower consumption. Bristols have tackled the problem and appear to have solved it with the *Orpheus*. This engine has been running for three months, and by mid-1955 the *Midge* converted into the *Gnat* by this more powerful engine will be in use as a flying test bed.

The United States are closely following these various developments. Last year they decided to allocate $50,000,000 to finance a number of projects prepared in Europe that might be of value for the defence of the West. The programme for a light tactical fighter is one of these projects. Inter-Allied groups of experts are examining the programme in all its aspects and are sorting out the specifications of the various prototypes that have been submitted to them as a preparation for making their choice. As they have to judge from drawings and not from the performance of aircraft having made certified tests, their task is not easy. Yet the stake is high: *to provide the Allied forces in Europe with a tactical air power that will be efficient in the atomic age*. However, the contest has another significance as well. This is the first time that the Allies have agreed to design separately, but on the same programme, air equipment for common use.

Unconfirmed picture of a model of the Bristol *Orpheus* medium-power axial-compressor turbojet, as published in the French "Aviation Magazine".

Programmes and Projects for Pocket-Size Combat Aircraft

Why modern combat aircraft are so costly, and whether the "stripping" of an aircraft must necessarily reduce its combat efficiency are questions which *Interavia* tackled nearly three years ago (No.7, 1952). Since then this problem, which is a particularly thorny one for the Western European countries with their limited financial resources, has been widely discussed, but no solution has been found. The problem still exists in all its acuity.

Take, for example, the case of *Britain*. The situation at the beginning of 1955 was that, despite "super-priority" grading, the output of up-to-date fighters and fighter-bombers is lagging behind schedule. There have been heated discussions in the House of Commons, and in mid-December Labour Members Wyatt and Beswick asked "Does the Prime Minister consider it satisfactory that after three years and an expenditure of £300 to £500 million the R.A.F. has fewer than 40 modern swept-wing British aircraft? . . ." The same Members also wanted to know why the Government did not give the Folland *Gnat* pocket-sized combat aircraft a try; its *Midge* predecessor had already been shown at Farnborough in 1954. The Minister of Supply's replies have so far been evasive, and the R.A.F. is still waiting.

In *France* deliveries of the Dassault *Mystère* fighter are running according to plan, but French orders are not big enough to meet real requirements, largely because of lack of funds.

Much the same applies to *Italy*, where only a relatively small number of American F-86K *Sabre* all-weather fighters is being assembled by Fiat under an off-shore contract, from finished parts supplied by the United States.

All this shows that Western European production of combat aircraft is inadequate and that, if the United States and Canada had not stationed a few thousand F-86 and F-84 fighters and fighter-bombers in Western Europe and the British Isles or supplied them to the European air forces, the West would have virtually no air cover.

At regular intervals projects for more economical future aircraft are prepared and offered to governments, but so far the official procurement authorities have not been able to make up their minds. Is it that they cannot or will not relinquish the dream of the "perfect combat aircraft", the luxury super weapon which not only has very high speed, rate of climb and range but also carries heavy armament and ammunition and everything of the latest in the way of radio, navigation and radar equipment? In addition, pressure cabin, power-boosted controls, autopilot and a model collection of other automatic equipment are regarded as obvious necessities, regardless of the operational mission. Such an outlook inevitably leads to heavy and very costly aircraft.

On the other hand the advocates of light-weight construction and derefinement methods argue with telling logic that every extra pound of equipment raises the aircraft's gross weight by 10 to 15 pounds . . . if performance is not to be sacrificed.

All this, of course, is grist for the mill of the British Opposition Members, who can point to the fact that the projected Folland *Gnat* would have the same performance—if not higher—as the Hawker *Hunter*, with only half the equipment weight and half the gross weight of the *Hunter*, and would hence be much cheaper to build and maintain and would consume much less fuel.

*

There are two ways, which can be followed either separately or together, of limiting the military equipment of fighters and fighter-bombers to the useful minimum:

— Transfer of as much equipment as possible from the aircraft to the ground control station;

— Specialized equipment for the aircraft, depending on its operational mission.

Why must short-range interceptors for home defence be equipped with heavy ILS instrument landing equipment, radio compass, autopilot etc., when a simple R/T system should suffice to "talk it down" to a safe landing by the GCA method even in the worst of weather? The Ground Controlled Approach system is after all merely the ground controlled interception method such as was used during World War II, in reverse. Since then the system has been further developed, though certainly there is still room for improvement, particularly in the ground equipment.

As regards the specialization of aircraft, the guiding principles here will have to be the three main tasks of the Western European air forces:

— short-range interception;

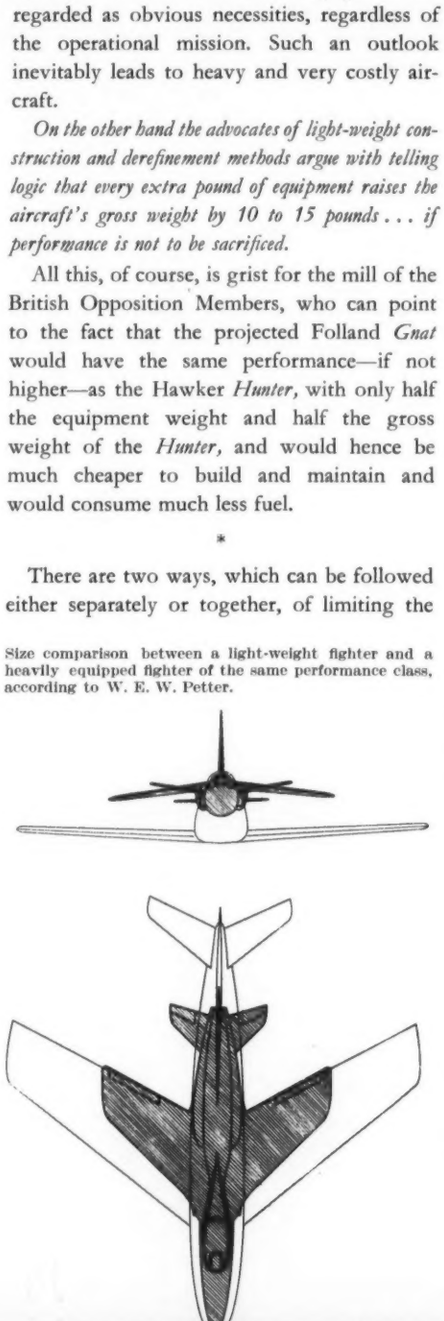
— ground support and interdiction of enemy supplies;

— naval support and anti-submarine operations.

The choice is either a small number of costly "super aircraft" or a large number of cheap light-weight aircraft. Whereas super aircraft as a rule are multi-purpose models, light-weight aircraft must fundamentally be specialized. A light ground support aircraft without pressure cabin, for instance, could not be used to intercept high-flying bombers. This gives the following juxtaposition.

Heavily equipped multi-purpose aircraft	— Light-weight fighter — Light-weight ground attack aircraft — Light-weight naval attack aircraft

Size comparison between a light-weight fighter and a heavily equipped fighter of the same performance class, according to W. E. W. Petter.



Light-weight fighters

Designed primarily for the defence of industrial and transport installations and

residential areas in home territory, and to provide air cover for land and air units in the theatre of operations, today's short-range interceptors have to meet particularly heavy demands. In particular they must have a *very high rate of climb* (aim: 50,000 ft. in less than ten minutes); service ceiling above 50,000 ft.; and *supersonic speed in level flight*. This makes the fitting of afterburners or auxiliary rocket engines for short-period thrust increase almost indispensable.

As armament for light-weight fighters two 30-mm cannon plus a number of rockets will usually suffice. Gyro gun sights, pressure cabin and ejection seat are essential; however, there is no need for heavy armour.

A glance at the known prototypes and projects gives the following rough picture:

UNITED STATES

Lockheed F-104A: Straight-wing day fighter of low aspect ratio; span approx. 28 ft., gross weight 18,000 lbs.; with its **Wright J-65 turbojet and afterburner** is said to reach speeds corresponding to Mach 1.5; small batch in production for the U.S. Air Force.

Ryan XF-109: Vertical take-off fighter prototype of undisclosed span and wing shape, with approx. 8,000 lbs. gross weight; **Rolls-Royce Avon** turbojet of approx. 10,000 lbs. static thrust.

GREAT BRITAIN

Folland FO.141 Gnat 1: Prototype of a swept-wing day fighter; span approx. 20 ft. 8 ins., gross weight approx. 6,000 lbs.; designed to reach Mach 1.2 and ceiling of over 50,000 ft., with a **Bristol Orpheus turbojet and afterburner** of approx. 7,000 lbs. static thrust. A **Gnat 2** ground attack version is also in preparation.

FRANCE

S.N.C.A.S.O. SO.9000 Trident: Prototype of the SO.9050 day fighter with straight wing spanning approx. 25 ft.; gross weight about 11,000 lbs.; **with two Armstrong Siddeley Viper turbojets** of 1,640 lbs. s.t. each at the wing tips and a **SEPR rocket engine** in the fuselage rear, the prototype is said to reach Mach 1.5-plus. Flight testing is in progress; two pre-production models of the SO.9050 are under construction.

ITALY

Aerfer Sagittario 2: Projected day fighter with 45° swept wing of approx. 25 ft. span; gross weight approx. 8,800 lbs.; **Rolls-Royce Derwent 9** turbojet of 3,600 lbs. s.t. plus (possibly) **auxiliary rocket engine.** Estimated performance not known.

As may be seen, the light-weight fighter is not necessarily a "light" fighter. If, however, the weight of the Lockheed F-104A (18,000 lbs.) is compared with that of "heavily equipped" modern fighters—e. g. North American F-100A (26,500 lbs.), McDonnell F-101A (40,000 lbs.), Convair F-102A (35,000 lbs.)—the difference is striking. Performance is approximately similar in all cases, though a substantial increase in weight was unavoidable in the F-101A *Voodoo*, which was designed as a long-range escort fighter, and the F-102A all-weather fighter and guided missile carrier.

France: S.N.C.A.S.O. SO. 9000 *Trident*, experimental model for the SO. 9050 supersonic fighter under development, takes off with both turbojets and SEPR rocket engine.

Great Britain: The Folland FO. 139 *Midge*, experimental forerunner of FO. 141 *Gnat 1* under development, was one of the interesting novelties at Farnborough in 1954.

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Light-weight ground attack aircraft

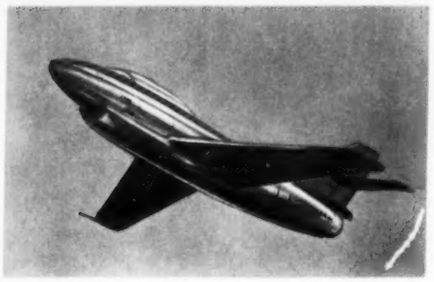
It is a well-known fact that N.A.T.O. has for some time been looking round for light low-level attack aircraft to operate from grass runways. These aircraft would be primarily for use for ground support and interdiction of supplies in the enemy's rear; i. e., they would perform tasks hitherto given to the fighter-bomber. Nevertheless N.A.T.O. officers in Paris must have felt their hair stand on end when they opened the American magazine *Aviation Week* for March 8th, 1954 and read the following report by McGraw-Hill's former London correspondent:

"*London*—North Atlantic Treaty Organization's 'want ad' for a ground attack fighter... appears to follow W. E. W. Petter's design of the Folland *Gnat*, Britain's first light fighter project.

"Initialed by N.A.T.O. air deputy Gen. Lauris Norstad, the proposal calls for 30 ground attack fighters to be delivered by January 1957. Contractor must meet the following specs:

Italy: Aerfer-Ambrosini-Stefanutti *Sagittario 2* interceptor project.

Pocket-Size Combat Aircraft



Italy: Fiat G.91 single-seat ground attack project.

● "*Mach .95* for 30% of missions, 350 knots for rest. Emphasis is laid on rate of roll of 100 deg. sec. at Mach .90 at sea level.

● "*Clear 50-ft. obstacle* within 3,000 ft. on takeoff from grass strip if necessary.

● "*Be capable* of carrying either of two types of armament: two 20-mm cannon with 200 rounds, or two 30-mm cannon with 120 rounds; Gyro gunsight and rocket sight is necessary, but radar ranging and tracking equipment are not; or, 12 three-in. rockets plus two 500-lb. bombs plus two napalm bombs; light armor required.

● "*Empty weight* of aircraft not to exceed 5,000 lbs . . .

"Equipment for N.A.T.O.'s ground attack weapon should include: pressurization installation and anti-G suit; radar homing beacon; VHF; DME (UHF homing responder); IFF; air brakes.

"Not necessary are pressurized cockpit and airborne radar. Aircraft is needed primarily for operations from zero to 5,000 ft.; it is needed for interception only on an emergency basis for which radar homing beacon is provided.

"*Typical mission*—A typical mission for this aircraft would look something like this:

- "150-mi. sortie at 350 knots.
- 8–10. min. search at same speed.
- 90-mi. getaway at Mach .95.
- Finish sortie at low speed (presumably over friendly territory).

"Tentatively earmarked for the successful manufacturer in this venture is $10 million from Special Weapons Development Fund appropriated by Congress last year. Money would go for development costs rather than for procurement . . ."

Naturally S.H.A.P.E.'s Paris headquarters have never admitted how far these details correspond to the real programme. It is assumed here that they probably go quite a long way. Such carefully coordinated details must surely come from some reliable source.

From the Makers of the Bréguet Taon

THE MINIATURIZATION OF AIRCRAFT

By Edmond de la Gabbe, Technical Director of Sté des Ateliers d'Aviation Louis Bréguet, Paris

The advantage of reducing the weight and size of single-seat interceptors or ground support aircraft has been sufficiently stressed of late to encourage manufacturers to build engines and equipment to fit the new concept. For example, a number of French and British firms have designed medium-thrust jets which are now undergoing bench tests and are to be installed in "light" aircraft.

These engines will give them a sufficiently high thrust weight ratio to ensure that their rate of climb and max. speed are higher than those of the combat aircraft now in service. The reduction in weight of these aircraft is accompanied by a reduction in wing area and hence in aerodynamic drag.

However, reducing weight, simplifying equipment and hence lowering production costs would be of little value if the finished aircraft were still dependent for take-off and landing on the present long concrete runways, which would inevitably be knocked out almost immediately in the event of war. The swing of opinion against the constant increase in the weight and power of military aircraft and hence against their basic design principles has enabled other developments to come forward. In particular, it has been recognized that the severe limitations imposed by the use of long concrete runways, the need for which was unknown in 1939, must be abolished.

Military staffs have thus imposed new conditions by insisting that aircraft must be able to use grass fields, if necessary hastily prepared, less than 1,000 yards in length, with 50-ft. obstructions round them. These are dimensions which are found frequently enough in Europe's topography. Moreover, use of such fields would give military units the dispersal and mobility that are essential to them in operation.

In designing new types of "light" aircraft to meet these needs, manufacturers have had to solve new problems. It has not only been a question of reducing all dimensions of a present aircraft to a smaller scale, with the exception of the pilot's cockpit, which obviously cannot be reduced to the same extent, though the instruments and equipment required are less numerous and less bulky. It was also necessary to fit larger undercarriages and more efficient high-lift devices.

In the general miniaturization of the classic combat aircraft, tyres, wheels, and the remainder of the undercarriage had to be made bigger to allow for the pressure permissible on ordinary ground; they thus occupy a relatively larger share in total size and weight. Undercarriage track, too, could not be reduced to below a certain width, as otherwise the aircraft would not taxi safely in a cross-wind. Solutions to these new demands by the military users were thus particularly difficult to find, in view of the thinness of the wing and the reduced space available in the fuselage.

In addition, the wings had to be equipped with effective high-lift flaps, to enable them to retain the wing loading needed for high performance. The normal devices cannot be used with wings of a sweep approaching 45° without compromising the aircraft's stability or manoeuvrability. New aerodynamic investigations had to be undertaken. Well-known problems of structural weight, strength and rigidity, aeroelasticity and flying qualities, speed range at altitude . . . in short all the problems whose common solutions determine the optimum characteristics of the aircraft and its adaptation to the proposed programme, had to be solved simultaneously.

The light-weight combat aircraft had to be completely "rethought" and "reworked", while retaining its qualities of robustness and ease of production and maintenance. Such a result could be obtained only through a judicious compromise between contradictory requirements. The art of the designer lies in the choice of this compromise.

This is how aeronautical engineering progresses, even in the field of small aircraft, through the long and persevering work of engineers and technicians constantly seeking new solutions to meet new needs.

The following is a list of the likely competitors:

GREAT BRITAIN

Avro 725 (?): Project for a delta-wing single-seat ground attack aircraft modelled on the experimental Avro 707, with one or two medium-powered turbojets (Bristol **Orpheus?**). — No further details available.

Folland Gnat 2: Projected ground attack version of the **Gnat 1** (see above) with Bristol **Orpheus** of approx. 4,850 lbs. s.t.; under construction.

FRANCE

Bréguet 1001 Taon: Projected ground attack single-seater with swept wing and one Bristol **Orpheus** turbojet of approx. 4,850 lbs. s.t. — No further details available.

Bréguet 1002: Projected ground attack single-seater with swept wing and **two turbojets** (S.N.E.C.M.A., Hispano Suiza or Turboméca (?) of approx. 2,200 lbs. s.t. each). — No further details available.

Dassault Mystère 26: Project of a sharply swept single-seat ground attack aircraft (approx. 45° at 25% chord) spanning 25ft. 5ins., with Bristol **Orpheus** turbojet of approx. 4,850 lbs. s.t.

ITALY

Fiat G.91: Project of a slightly swept single-seat ground attack aircraft of undisclosed span, with Bristol **Orpheus** turbojet of approx. 4,850 lbs. s.t. — No further details available.

Slightly outside this series is the single-seat *SNCASE SE. 5000 Baroudeur* swept-wing ground attack aircraft with a span of approx. 32 ft. 10 ins. and a gross weight of 14,300 to 20,500 lbs., which can take off from a trolley on a grass runway and land on skids (cf. *Interavia* No. 3, 1954), but is considerably above the weight specified by N. A. T. O. Nevertheless, a number of these aircraft are under construction for the French Air Force.

Light-weight naval attack aircraft

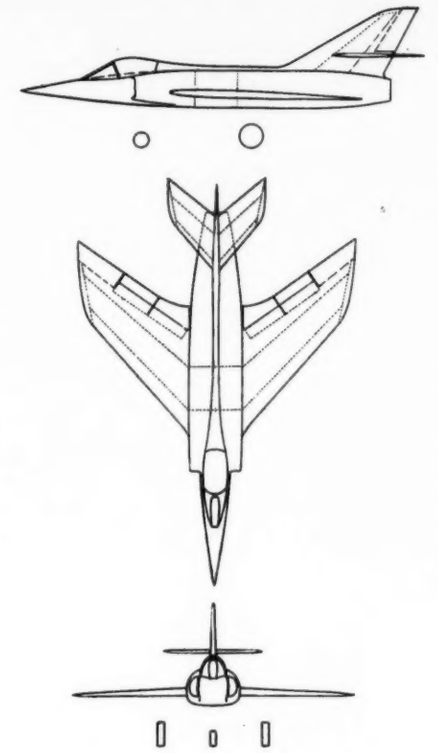
Designed particularly to keep open vital sea communications in wartime, i. e., to detect and attack enemy submarines, but also for interdiction missions in enemy coastal areas, the carrier-based naval combat aircraft are the "stalking horses" of the American and British navies. The heavily equipped naval strike aircraft, such as the Douglas A3D *Skywarrior* and the Westland *Wyvern,* have been joined in recent months by a number of definitely light-weight types:

UNITED STATES

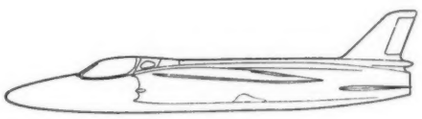
Douglas A4D Skyhawk: Multi-purpose single-seater (can also be used as atom-bomber) with "moderate" delta wing spanning 25 ft.; gross weight approx. 15,000 lbs.; **Wright J-65** turbojet of approx. 7,200 lbs. **without** afterburner (cf. article by E. H. Heinemann elsewhere in this issue).

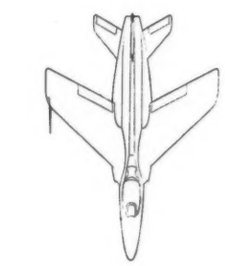
GREAT BRITAIN

Short Seamew: Two-seat anti-submarine aircraft which can be operated from auxiliary fleet carriers, with unswept wing spanning 55 ft., or 23 ft. when folded. Powered by an **Armstrong Siddeley Mamba turboprop** of approx. 1,600 e.h.p. Developed especially for quantity production.



France: Dassault *Mystère 26* single-seat ground attack project.





Great Britain: Folland *Gnat 2* single-seat ground attack project.

Turbojets for the projected light-weight combat aircraft

Leaving aside the definitely high-power J-65 *Sapphire* engine preferred by the Americans, there are at present two engine types particularly suitable for light-weight aircraft:

Bristol Orpheus: in development; turbojet with seven-stage axial compressor and single-stage turbine; cannular combustion chamber with 8 flame tubes; 97 ins. long and 32 ins. in diameter; dry weight 850 lbs.; fuel consumption 0.97 to 1.1 lbs./lbt.h; projected max. thrust 4,850 lbs. without, 7,000 lbs.-plus with afterburner.

Armstrong Siddeley Viper: turbojet with seven-stage axial compressor and single-stage turbine; annular combustion chamber; under construction in both a short-life and a long-life version, e.g., at Avions Marcel Dassault. The ASV.5 long-life version delivers a static thrust of 1,640 lbs., is 65.4 ins. long and 28 ins. in diameter; dry weight approx. 465 lbs.; fuel consumption 1.09 lbs./lbt.h; afterburner version in preparation.

It is also reliably reported that the French engine firms of *S.N.E.C.M.A., Hispano Suiza* and *Turboméca* are each working on a medium-powered turbojet, though no details are yet obtainable.

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Summing up, it may be said that though there is much discussion in Europe on the subject of light-weight combat aircraft, and a number of interesting projects have already been produced, it is in America that the only fully developed aircraft of this class—the Lockheed F-104 and Douglas A4D *Skyhawk*—are flying. However, Europe has made one noteworthy special contribution, in the Short *Seamew*. The decisive question for European development is whether the Bristol *Orpheus* engine, into which substantial sums of money have been put, can successfully complete its test runs within the near future and be supplied in quantity.

Great Britain: Short *Seamew* carrier or land-based turboprop naval combat aircraft with airborne radar for submarine detection.

Design of Lightweight, Simplified Combat Aircraft

BY E. H. HEINEMANN, CHIEF ENGINEER, EL SEGUNDO DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.

Editors' Note: An atom-bomber weighing less than 15,000 lbs. at take-off and capable of performing about a dozen other missions is the latest achievement of 47-year-old Edward H. Heinemann, Chief Engineer of the El Segundo Division of Douglas Aircraft Company. The tall, somewhat self-conscious engineer was born at Saginaw, Michigan, in 1908. His father was also born in Michigan, but his mother came from Basle, Switzerland. He moved to California with his parents at the age of six.

Heinemann, creator of what the U.S. Navy considers as one of its most advanced combat aircraft, ended his formal education with high school at the age of 17. But through self-study and practical experience, flying lessons and parachute jumping, he acquired a vast knowledge of aeronautical engineering, with the result that aircraft he has designed were first to fly higher than 15 miles (**Skyrocket,** 83,235 feet), were first to travel at Mach 2 (**Skyrocket,** 1,327 m.p.h. at altitude), and hold the official world speed record (**Skyray,** 752.9 m.p.h.).

His first job, when he was 17, was on the design of custom-made truck trailer and fire-engine bodies for a Los Angeles manufacturer. In 1926 he joined Douglas Aircraft as a draughtsman but left in 1927 to work for several other aircraft manufacturers in succession. In 1931 he returned to Douglas and five years later he became Chief Engineer of what today is known as the Douglas El Segundo Division. Heinemann was honoured last year by the award of the Collier Trophy for "achievement in Aviation in America", which followed the presentation to him of the Sylvanus Albert Reed Award for "the most notable contribution to experimental aeronautics" in 1951. His aircraft have employed piston, turboprop, jet and rocket engines and have featured straight, swept and delta wings.

In recent years Ed Heinemann has become a strong advocate of a reversal of the aircraft design trend towards heavier, more complex and expensive aircraft. He is preaching simplicity in design to eliminate "gadgetry" or what he calls tack-hammer engineering—"tacking extra things on which could have been avoided with a little forethought". He points out, for example, that twenty-five years ago $ 100,000,000 bought 1,100 fighter aircraft, whereas five years ago it bought less than 100.

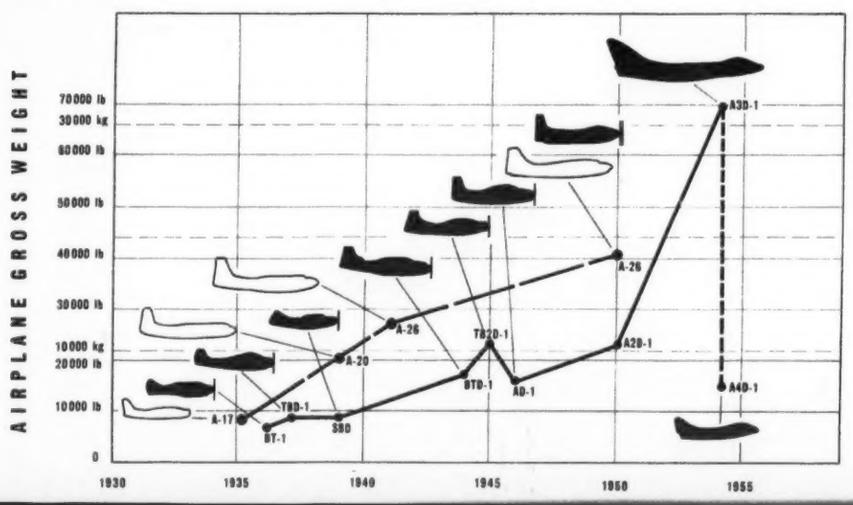
His latest achievement is the A4D **Skyhawk**, or the "Heinemann Hotrod" as it is called in his honour, which the U.S. Navy has now ordered into production.

During recent years there has been much discussion among aircraft designers of the current trend toward heavier, more complex aircraft. Individually these designers may differ, but whether they favor lightweight aircraft or larger, more complex designs, basically their design philosophies are the same—to produce an airplane giving the greatest combat effectiveness for a particular mission. Experience has proven that weight and complexity are the two arch enemies not only of design, but also of safety, maintenance, and quantity production. The problem therefore appears to be how to arrive at the inevitable compromise between simplicity and complexity without sacrificing safety or performance.

Fig. 1 : Design drawing of a Douglas A4D *Skyhawk* naval combat aircraft ready for a catapult take-off.

During the war years there was a marked increase in the weight of combat aircraft as shown in *Figure 2.* Demands were made upon the aircraft manufacturer for an airplane not only with increased performance, but also with new navigational and radar aids and advanced electronic and mechanical equipment made possible by rapid technological advancement. The pressure of war required an all too rapid expansion of engineering departments and forced new designs into production without benefit of the engineering needed to refine them to a maximum degree of efficiency.

Fig. 2 : Gross weight trend in Douglas ground attack and naval attack aircraft from 1935 to 1955. — The A-17, A-20 and A-26 ground attack aircraft, designed for the U.S. Air Force, were all land-based, while the BT-1 to A4D-1 series of naval attack aircraft were developed for use by the U.S. Navy on board aircraft carriers. Contemporary models by other manufacturers were nearly all considerably heavier than the Douglas types covered here. It should also be noted that the twin-jet A3D *Skywarrior* was designed for substantially longer ranges than the AD *Skyraider* or the A4D *Skyhawk.*



Almost ten years have elapsed since World War II, and the mistakes made in the designs of that period have been analysed and corrected, and although what has been learned has obviously not reversed the weight and complexity trend it has pointed the way to substantial improvements which not only can but *have* been made.

The El Segundo Division of the Douglas Company has had the good fortune since the war of designing a series of airplanes for the U. S. Navy of a wide variety of types, all carrier-based, so that it has been possible thoroughly to investigate ways of reducing

weight and complexity and at the same time methods of increasing performance. Perhaps it can be said that El Segundo is doubly blessed in having these designs occur in such a manner that their engineering department has been able to work on one model after another so that experiences gained with one could be applied directly to the next, thus creating a very high degree of stability in its design organization.

While comparisons are a bit dangerous, it is rather interesting to note that the last six combat designs from the El Segundo engineering department have weighed approximately one-third less than competitive aircraft or the weight permitted by military requirements. This difference did not come accidentally or easily. It was a deliberate effort to approach the airplane design problem fundamentally and resulted in developing airplanes tailored to the pilot and the weapons he had to deliver in the most efficient manner for the particular state of technological advancement of the time. This design effort was accompanied by an educational program which not only affected those involved in the manufacture of the airplane but also the equipment industry who, once they understood the importance of the problem, did much toward reducing the weight of their equipment, thus reducing the airplane weight.

Very instrumental in bringing about the realization of the importance of weight saving among the equipment and airframe designers was the introduction and use of the term "growth factor". The term in this sense refers to the factor by which the added equipment weight must be increased to obtain the increase in airplane weight necessary to maintain constant performance and strength.

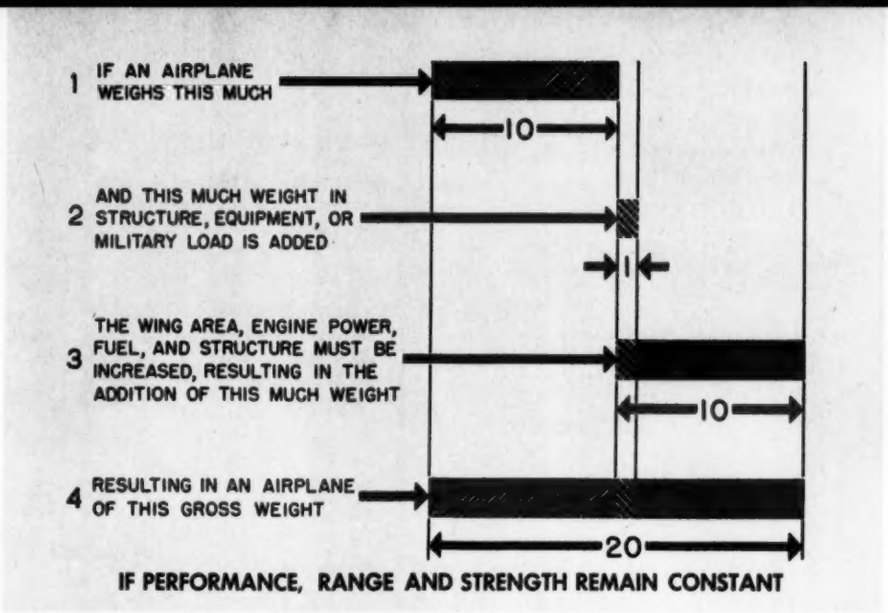

1 IF AN AIRPLANE WEIGHS THIS MUCH
10
2 AND THIS MUCH WEIGHT IN STRUCTURE, EQUIPMENT, OR MILITARY LOAD IS ADDED
1
3 THE WING AREA, ENGINE POWER, FUEL, AND STRUCTURE MUST BE INCREASED, RESULTING IN THE ADDITION OF THIS MUCH WEIGHT
10
4 RESULTING IN AN AIRPLANE OF THIS GROSS WEIGHT
20
IF PERFORMANCE, RANGE AND STRENGTH REMAIN CONSTANT

Fig. 3: Example of the effect of a 10 % increase in weight in a jet aircraft with a growth factor of 10.

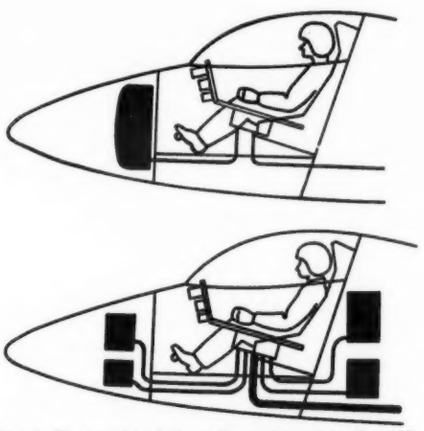


Fig. 4: The weight of the radio equipment in the A4D before repackaging (lower drawing) totalled 158 lbs. while "integration" of this equipment into a single package reduced weight to a total of 110 lbs.

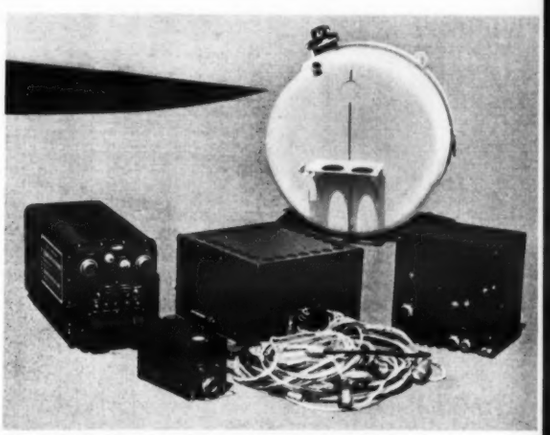


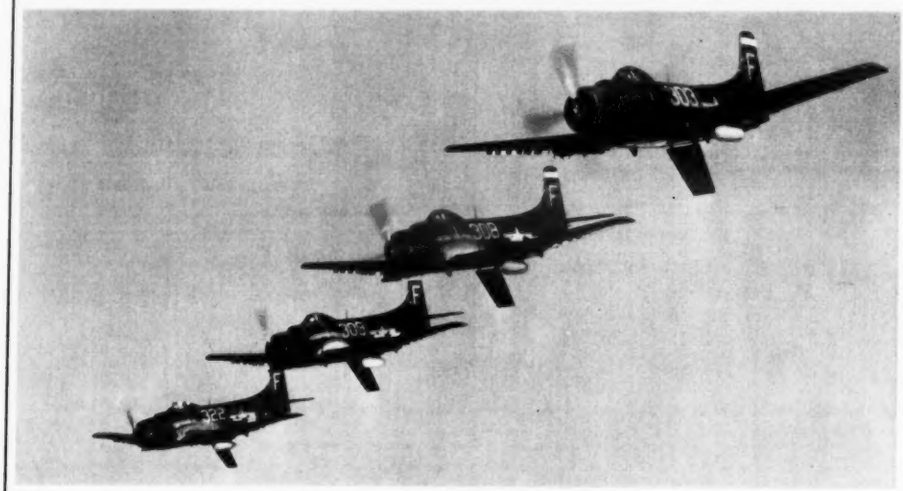
Fig. 5: In the foreground are communication equipment with navigation auxiliaries (left, 81 lbs.), amplifier and power supply (centre, 12 lbs.), identification equipment (right, 40 lbs.) with wiring and brackets (25 lbs.) designed to the old AN specification for low-level attack aircraft. All this equipment was repackaged for the A4D inside the white cylinder (rear), which weighs only 105 lbs., plus 5 lbs. for wiring and brackets.

Fig. 6: These two seats were designed for the same military purpose. Whereas the left-hand seat consists of 240 parts and weighs 98 lbs., the right-hand one contains only 80 parts with a total weight of 40 lbs., i. e., it is 59 % lighter.

The growth factors of various airplane designs vary considerably, depending on the airplane type. For example, an AD *Skyraider* propeller-driven airplane has a growth factor of approximately 4.3 whereas the F4D has a factor of 10; the A3D of 8, and so forth. Some new designs are said to have factors as high as 15 or greater.

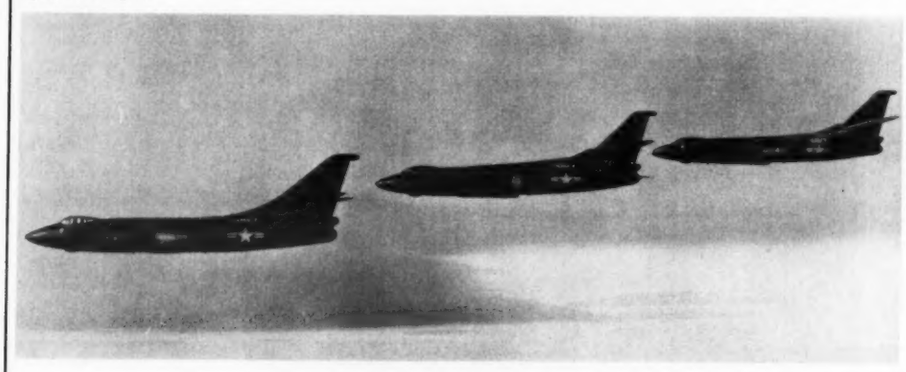
In using this growth factor as a lever to reduce airplane weight, a factor of 10 is considered a reasonable average and has proven quite effective. *Figure 3* is an illustration of how, if an airplane design has one-tenth its weight added to it, the wing, fuselage, engine power and fuel must all be increased by a factor of

Recent Douglas Naval Combat Aircraft



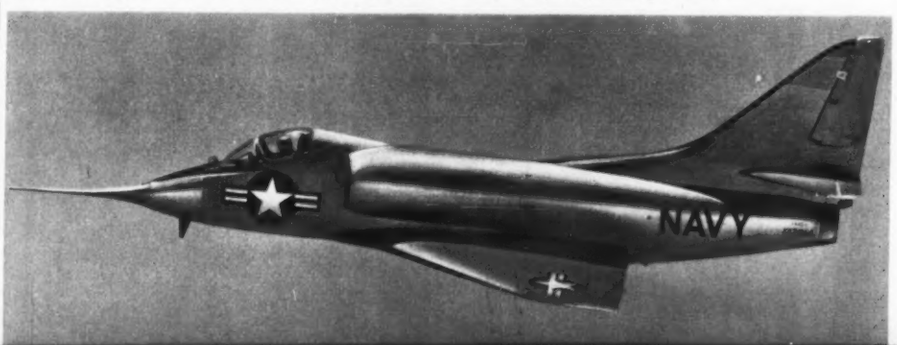
AD Skyraider: A group of four of these versatile multi-purpose aircraft (for crew of 1 to 3) with air brakes extended. Power plant in the last version, the AD-5, is an 18-cylinder Wright R-3350 *Cyclone* of 2,700 h.p. take-off power; span 50 ft., max. speed 365 m.p.h.

A2D Skyshark: Carrier-based single-seater with Allison T-40-A-6 dual turboprop of 5,850 h.p.; span 50 ft., max. speed 525 m.p.h.



A3D Skywarrior: Twin-jet carrier-based long-range A-bomber for crew of three. Power is supplied by two Pratt & Whitney J-57 turbojets of 10,000 lbs. thrust each; span 95 ft., max. speed "more than 600 m.p.h."

A4D Skyhawk: Carrier-based multi-purpose single-seater and "flyweight" among atomic bombers, with Wright J-65 turbojet of approx. 7,200 lbs. thrust. Speed is superior to many current fighters; span 25 ft.



10 resulting in a new gross weight of twice the original if performance, range and strength are to remain constant. It is realized that much equipment is added to airplanes already completed without increasing weight by the amount of the growth factor; however, in doing so the strength and performance are impaired, thus actually cheating the pilot out of the best that he might have been given.

Weight and complexity usually go hand in hand. In many instances it has been found that a heavy complex structure or mechanism can be critically reviewed and redesigned, eliminating parts, reducing man hours, cost, weight, and maintenance, and at the same time improving reliability and combat effectiveness. There are many examples of this, such as the repackaged communication equipment and electronic equipment shown in *Figures 4 and 5* and the redesigned ejection seat in *Figure 6*. These are but a few of the items where such a saving can be made but they illustrate well what is meant by the term "fundamental engineering approach" and the more currently popular term "system analysis". These savings alone, however, are not enough. The same philosophy must be applied to the design of the entire airplane.

*

Another and very important consideration in modern aircraft design is reliability, for there have been all too many cases where secondary systems have been added to faulty primary systems under the heading of improvement, only to reveal in the end that the reliability was lower than it would have been had similar effort been applied to the primary system. The most important considerations in increasing reliability are to consider the requirement in the broadest sense, to deal in fundamentals, and to reduce the number of components in a given system to the practical minimum.

Figure 7 illustrates, for example, that if 10 parts, each with a 99 percent *reliability* must work together in order to have a particular system function, the reliability of the whole system drops down to 90 percent; or if each of the 10 parts is only 90 percent *reliable* the overall effiency drops down to approximately 35 percent. This is one of the strongest arguments in favor of simplification.

*

Perhaps one of the best illustrations of designing for simplicity and minimum weight in the United States is the Navy's Douglas A4D *Skyhawk* airplane (cf. *Figs. 1, 8, 9, 10).* This airplane is a carrier based attack bomber designed for carrying atomic bombs, conventional bombs, guns, rockets and missiles. While

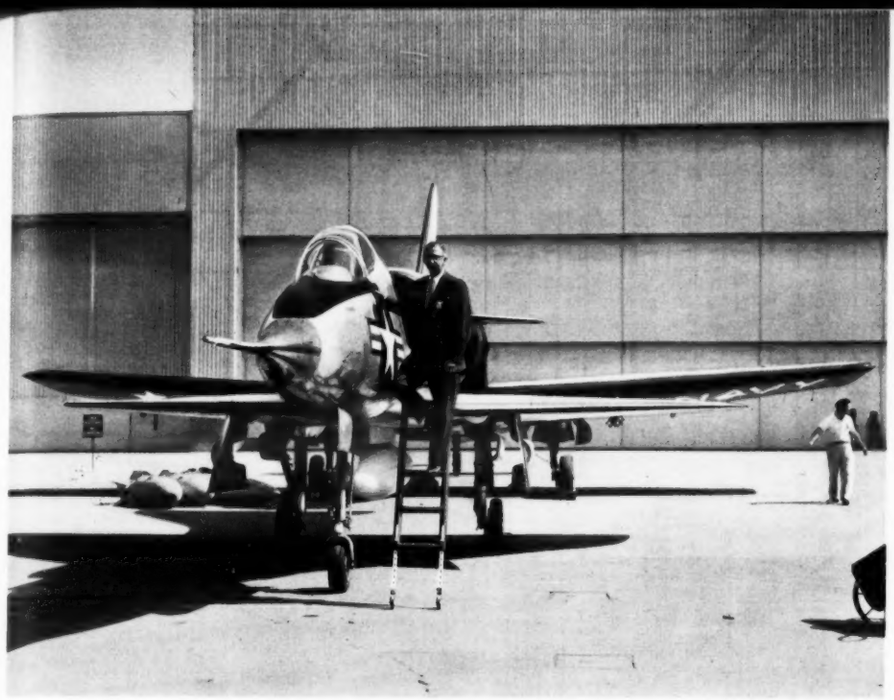


Fig. 9 : The author, Chief Engineer E. H. Heinemann, beside an A4D *Skyhawk*, parked in front of a Douglas AD *Skyraider* to demonstrate the structural differences. Even the streamlined bomb under the A4D fuselage – also developed by Douglas's El Segundo Division – differs favourably from the much clumsier version which the *Skyraider* had to lug along over Korea. The latter are shown underneath the *Skyraider's* starboard wing. Because of the size of some of the heavier bombs, the *Skyhawk* had to be given a long-legged undercarriage.

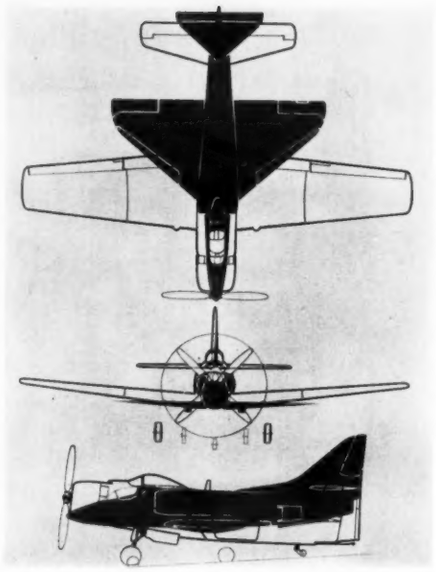


Fig. 8 : This comparison shows that the A4D *Skyhawk* has only a fraction of the target area of the AD *Skyraider*, thus increasing safety against gunfire and radar detection. As the A4D also flies approximately twice as fast as its predecessor and has an approximately 50 % greater combat radius, the comparison also illustrates how the light-weight design philosophy increases combat efficiency and pilot safety.

the *Skyhawk* is similar to the British Folland *Gnat* and *Midge* designs in philosophy, it differs somewhat in its tactical concept inasmuch as it was designed as *a multi-purpose airplane* from the outset and is capable of being converted into many *different* configurations.

The various weapons are carried externally on 3 bomb racks or in streamlined packages against the under-surface of the fuselage. Owing to the large size of the bombs this airplane must carry, it has one characteristic quite different from other small fighters in that it has a long landing gear. This feature, of course, added considerably to the weight of the airplane and to the design problems in general but it was most necessary to carry large bombs satisfactorily.

Originally conceived as a 30,000 pound turboprop airplane, this replacement to the AD's and A2D was finally reduced in size so that the final airplane weighs less than half that amount. So successful was the weight-saving effort that it was possible to keep the wing span within the folded span dimension required by the Navy for carrier-based airplanes. In turn this saved all the weight of the wing-fold hinges and mechanism.

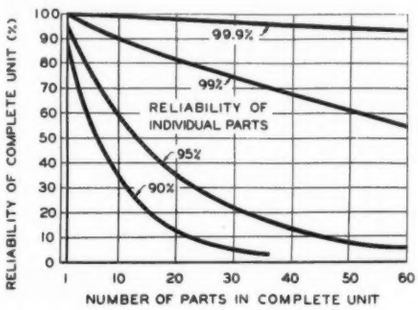
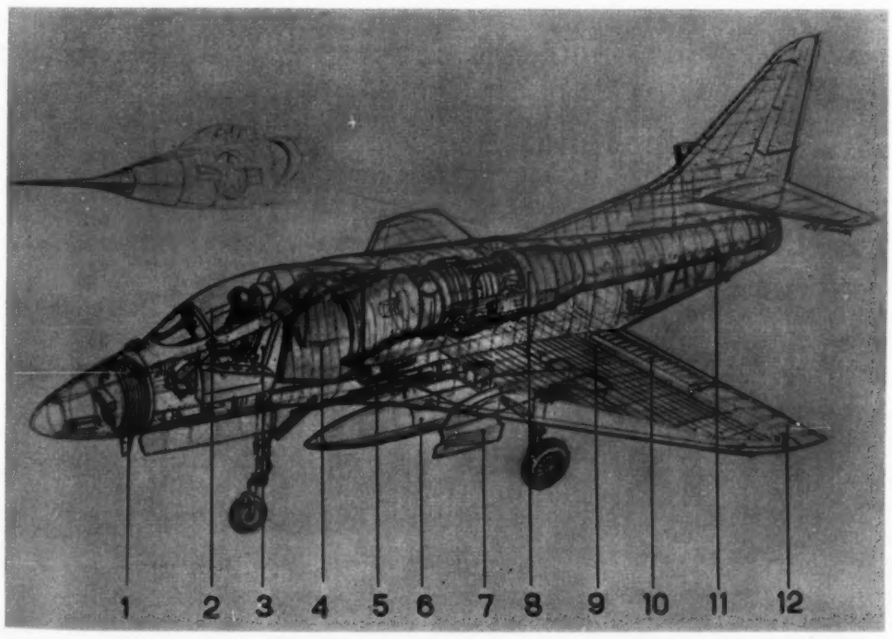


Fig. 7 : The reliability of any aircraft which consists of a number of parts in series (ordinates) drops by the nth power of their individual reliability, where *n* (abscissa) denotes the number of parts.

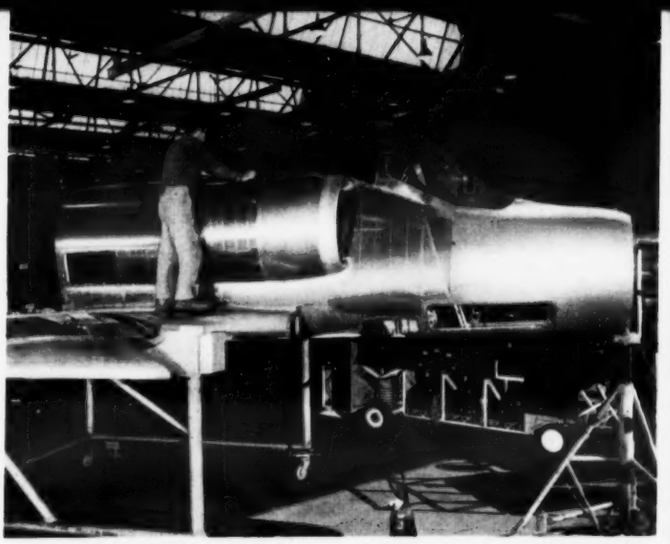
Fig. 10 : Design drawing of the Douglas A4D *Skyhawk*, showing from front to rear : 1 – radio equipment cylinder ; 2 – cabin roof (opened rearwards) ; 3 – ejection seat ; 4 – fuel tank in fuselage ; 5 – two cannon with belt drums ; 6 – streamlined bomb ; 7 – main wheel cover ; 8 – Wright J-65 turbojet ; 9 – main tank in wing ; 10 – landing flaps ; 11 – jet pipe ; 12 – aileron. Top left, the measuring sound in the nose of the prototype.



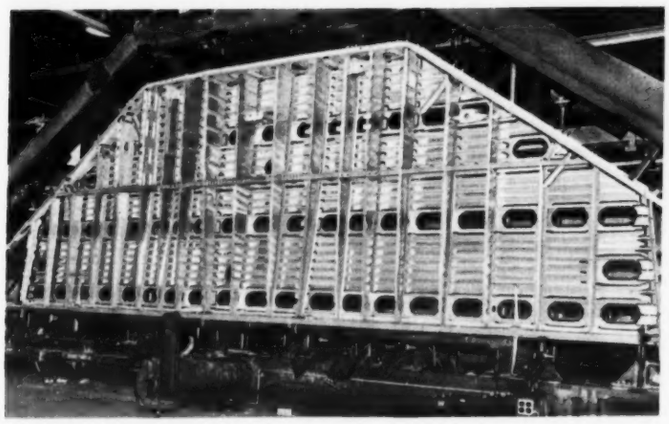
Admitting that this weight saving is very impressive, the first question usually asked is, "But what did you leave out of it?". The answer is that as an attack airplane with a long range requirement an afterburner was impractical. Therefore the afterburner weight was saved. This might not have been satisfactory if the airplane had been primarily a fighter, but as an attack airplane, it proved to be the proper solution. However, even without an afterburner, the A4D has a maximum speed somewhat faster than the Russian MiG-15.

There was nothing of importance omitted from the A4D. It has an ejector seat. It has full

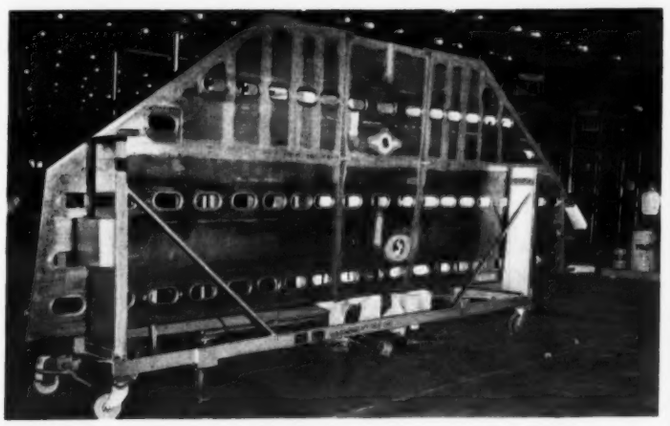
The Douglas A4D-1 is in production in substantial numbers. The one-piece rear fuselage with its giant fin.



The forward fuselage in the A4D is combined with the left and right air intake ducts and the cockpit into one sub-assembly.

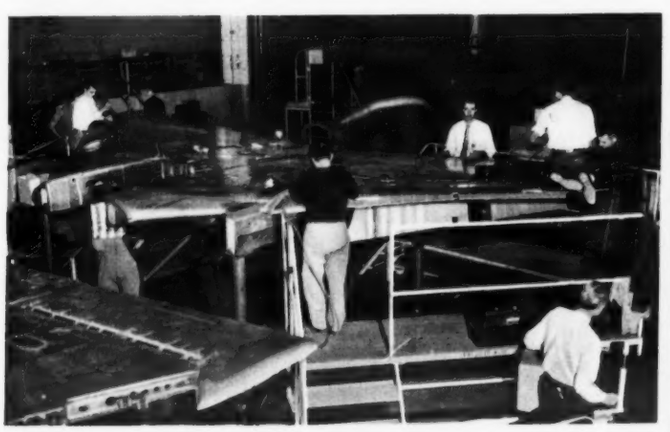


The semi-finished wing of the A4D, which also serves as giant fuel tank. The upper skin is already connected to the spars and ribs.



The wing frame – with completely riveted skin on one side – ready for transport to the next stage on the production line for fitting of the lower skin.

The remaining portions of the wing-tips, parts of the leading edge, ailerons, landing flaps – are fitted, with the wing on a horizontal stand.



The A4D has particularly large leading edge slats, which cover almost two thirds of the span.

The Wright J-65 turbojet is inserted in the forward fuselage before the rear fuselage is fitted.

Rear fuselage and tail plane are added, undercarriage, ejection seat and wind shield placed in position. A final check, and another A4D is ready for flight tests.

Fig. 11: The Douglas A4D, known in Navy circles as "Heinemann's Hotrod", in flight. Note the large deflection range of the elevator unit.

communication and navigation equipment, a bombing system and all the necessary instruments, although some of the instruments have been combined for improved reading and for weight and space saving. In fact, the entire cockpit was designed from a pilot's point of view, taking advantage of all the latest aeromedical knowledge in order to give the pilot every physiological and psychological advantage in flying the airplane in combat. After many different cockpit arrangements were mocked up the final cockpit mockup was shown to several hundred combat pilots, many having had recent combat experience in Korea. There were no major complaints.

Much credit for the development of the A4D *Skyhawk* is due to the engineers of the U.S. Navy Bureau of Aeronautics, as well as the Douglas engineers, who worked together wholeheartedly to break away from the weight and complexity trend of recent years. There were times during the formative stage of the project when it appeared almost impossible to make a gain of this order of magnitude and many experts volunteered that we would probably have to settle for 20,000 pounds in the end. The fact that the design gross weight of under 15,000 pounds was bettered is most significant and a tribute to all concerned, and it shows quite clearly that by more diligent engineering it does become possible to build smaller, lighter, less complex airplanes at greatly reduced costs to the taxpayer.

It is estimated in the quantity in which A4D's will probably be built it will be possible to build 2.4 times as many airplanes as it would have been had they weighed 30,000 pounds, since the quantity will be further down the cost learning curve. Based on very preliminary cost information it is estimated that for every thousand A4D's manufactured there will be a saving of the order of $400,000,000 over what the cost might have been had the airplane been designed for the original 30,000 pound gross weight.

The method of estimating used in arriving at this figure is of course an over-simplification but it does indicate the order of magnitude of such savings and clearly indicates that even though there may be some additional engineering cost involved, it is well worth while.

Fig. 12: All main components are quickly dismantled, in particular fuselage nose cap, radio cylinder, undercarriage, skin panels and fuselage rear (for removal of engine). Maintenance requires only few special tools.

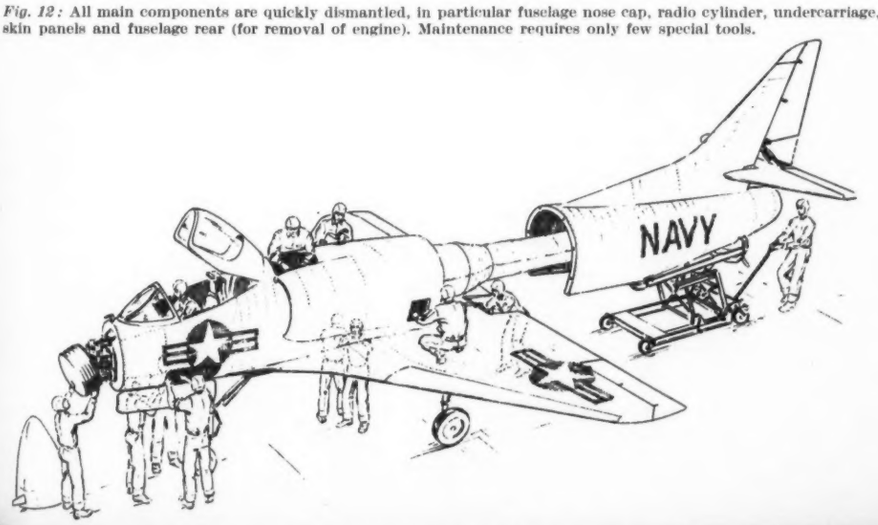


Fig. 13: Designed as a carrier-based interceptor and fitted with a Westinghouse J-40 turbojet plus afterburner, the Douglas F4D *Skyray* reaches supersonic speeds in level flight. In this aircraft James B. Verdin set up a world speed record of 1,212 km/h (752.9 m.p.h.) over a 3 km course in 1953.

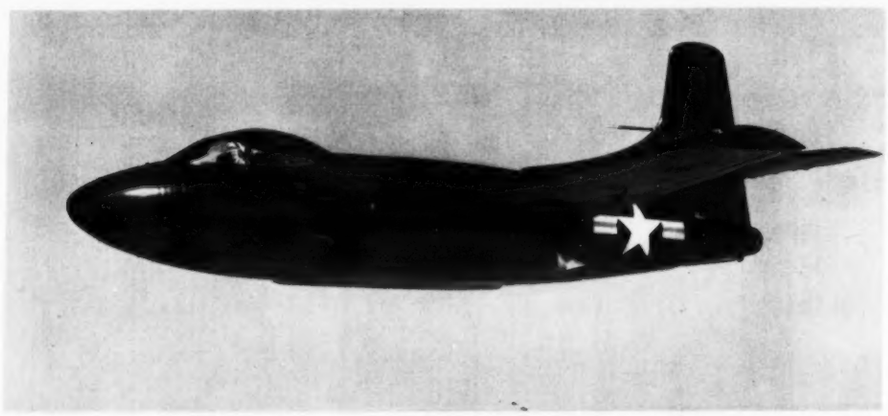


Fig. 14: The Douglas F3D *Skyknight* carrier-based twin-jet all-weather fighter (two Westinghouse turbojets) weighs approximately half its two nearest competitors. A successful veteran of the Korean war, the *Skyknight* was the first to shoot down opponents by radar at night.

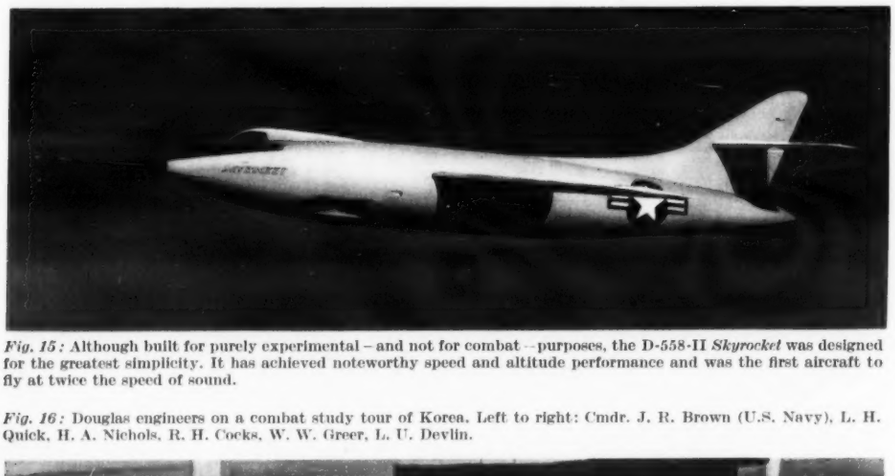
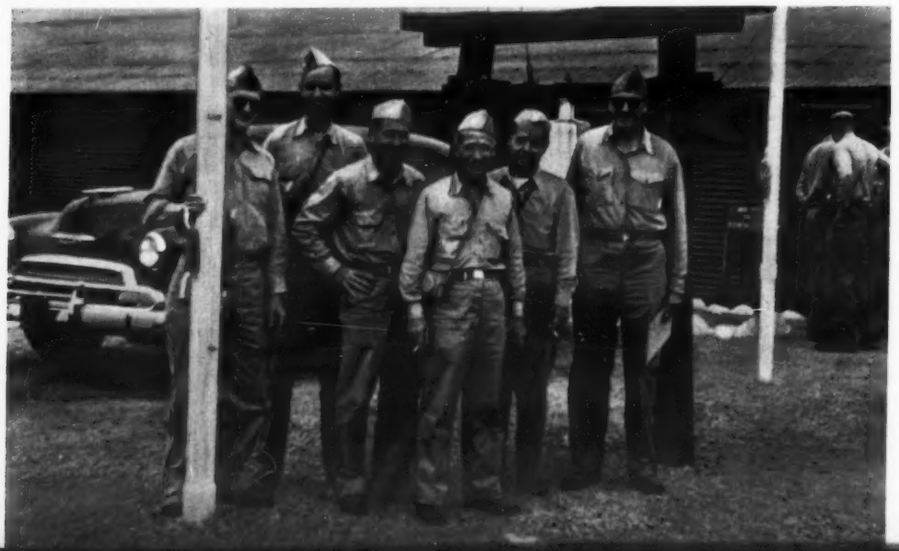


Fig. 15: Although built for purely experimental – and not for combat – purposes, the D-558-II *Skyrocket* was designed for the greatest simplicity. It has achieved noteworthy speed and altitude performance and was the first aircraft to fly at twice the speed of sound.

Fig. 16: Douglas engineers on a combat study tour of Korea. Left to right: Cmdr. J. R. Brown (U.S. Navy), L. H. Quick, H. A. Nichols, R. H. Cocks, W. W. Greer, L. U. Devlin.



There are of course many other advantages to military operating organizations. It is estimated, for example, that the A4D will require only 40 percent of the maintenance hours that would have been required had it weighed 30,000 pounds.

Fuel is another major item, especially for carrier use where the fuel supply is limited. In addition to having greater combat radius than its predecessors including the AD propeller driven airplane, the fuel consumption of the A4D is half of what it would have been at 30,000 pounds, at which weight it would have been necessary to use two engines instead of one.

The power plant of the A4D is a Wright J-65 *(Sapphire)* engine without afterburner. The engine is located in the fuselage aft of the pilot and is quickly removable by means of a detachable fuselage tail (cf. Fig. 12).

In addition to the great emphasis that was placed on minimum weight and simplicity in the A4D, its design represents the experience of jet airplanes operating in the Korean campaign, both carrier and land based. During the early design stages of the A4D a team of Douglas El Segundo engineers went into the combat zone to witness firsthand all of the operational and maintenance problems encountered under such conditions (cf. Fig. 16).

Among the featured characteristics are unusually good low speed handling qualities during landing approach and short take-off distances in the full load condition, thus requiring minimum runway lengths for land based operations. Maintenance improvements include quickly removable components, such as control surfaces and landing gears, as well as easy removal of the wing from the fuselage in order to facilitate maintenance and repair with minimum tools in combat areas. Many maintenance tricks have been learned. The shipping container for the electronics package, for instance, by a bit of ingenuity serves as a check stand for checking out the equipment before putting it in the airplane. Such service and maintenance details are only possible through close liaison between design engineering departments and the combat units.

*

It is believed that the characteristics of the A4D should make the airplane unusually well suited for a variety of uses, such as atomic bombing, strafing, interdiction with guns, rockets, bombs and napalm, as well as air patrol and fighter missions. The final test, however, can only come when it is placed in commission in operating squadrons.

Interview with W.E.W. Petter

C. B. E., B. A., F. R. Ae. S., MANAGING DIRECTOR AND CHIEF DESIGNER
FOLLAND AIRCRAFT Ltd., HAMBLE, HANTS

Editors' Note: *46-year-old William Edward Willoughby Petter, Britain's foremost pioneer of light combat aircraft design, has previously made himself a name as a "conventional" aircraft designer and as such was responsible for the English Electric* Canberra *jet bomber, the Westland* Whirlwind *and* Welkin *piston-engined fighters and, earlier, of the original Westland* Lysander *Army cooperation aircraft. In the last five years he has devoted his energies to the evolution of high-performance light-weight interceptors and ground attack aircraft, and the Folland* Midge *shown at the 1954 Farnborough Show is the forerunner of the Folland 141* Gnat *light-weight fighter which is scheduled to fly later this year. Petter's design philosophies were described in the September 1953 issue of* Interavia Review *under the title "Design for Production."*

Question: What was the fundamental reason for the Royal Air Force not adopting the Gnat light-weight fighter at the outset?

Answer: The R.A.F. did adopt the *Gnat* three-and-a-half years ago, but the decision came to nothing because no suitable engine was available, and the Ministry of Supply thought that it would take too long to develop an engine.

Question: If the Gnat were ordered now, how soon could it be in squadron service, now that a suitable engine is under development?

Answer: The first *Gnat* squadron could be formed about the middle of 1957.

Question: How valid are the Air Ministry's arguments that the Gnat cannot meet all present-day interceptor requirements in armament, equipment and guided missiles?

Answer: Basically, the *Gnat* meets all the requirements around which the *Hunter* was built, except that it carries only two instead of four guns. In my view the guns (30-mm cannon) are so powerful that the modern fighter does not need four—a view which is supported by the fact that there is now considerable disagreement among the experts about the number needed.

In the future, the needs of fighters designed specifically for the defence of this country will tend to become more specialised, and I think that types larger than the *Gnat* will be necessary. However, such machines would be too large and complicated to use overseas. They will also be too expensive to build in large numbers.

Question: Can the techniques and theories behind the Gnat be extended to cover a range of new fighters, both day and all-weather, in the future, and can Air Ministry requirements be met by them?

Answer: The basic ideas behind the *Gnat* could certainly be extended to cover a range of fighters, and there are one or two developments which could be started now for the defence of this country. But they would not, I am afraid, meet the requirements of the Air Ministry as at present defined. The *Gnat* theory could be the beginning of a new line of thought. It would require new thinking on the part of the Service specification writers and a more vigorous effort on the part of the radar and guidance people than we have so far seen.

Question: Do you agree with the present policies of duplicated control systems, airborne radar, for single-seat fighters and complex fire control systems, or can a simpler solution to the whole problem be found?

Answer: This question should be approached from the other end. We should ask ourselves what is the best machine we can build in adequate numbers without excessive use of skilled labour and of our resources in materials and money. We should then revise our tactics and weapons to suit.

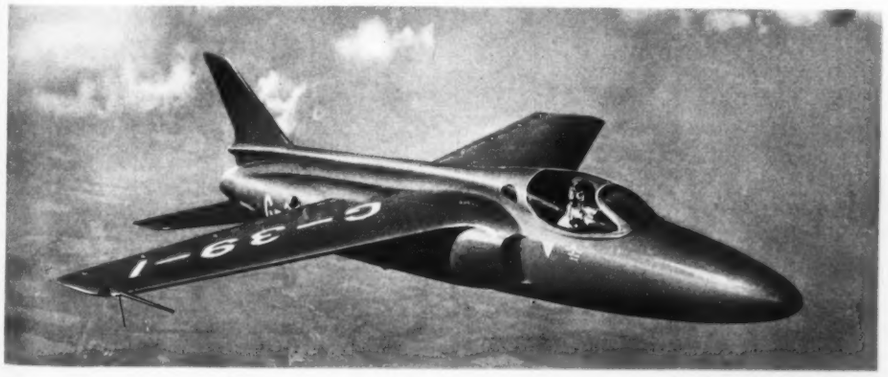
Question: Do you advocate for the future the use of so-called supersonic engines of great weight and complexity, or would you continue to develop the light-weight engine with special aids for increasing power output?

Answer: I believe that a good light-weight engine should be pushed to the limit of its capacity and that every aid for increasing output should be applied, provided that it confers a clear advantage. I regard "combination" power plants and so-called supersonic engines as being still in the research stage. We should take the light, simple and efficient engine and extract the utmost we can from it.

Question: Could you expand on your ideas for mass production and sub-contracting to get fighters into service?

Answer: Frankly, I think that only the light fighter lends itself to mass production—and that largely because it can be so extensively sub-contracted. All its detail parts are simple to make, there are few heavy forgings to be handled, and there are few, if any, difficult machining operations. I cannot think of any

With an Armstrong Siddeley *Viper ASV.5* of 1,640 lbs. static thrust the Folland FO.139 *Midge* experimental aircraft, predecessor of the *Gnat*, reaches level speeds of about 525 knots and supersonic speed in a dive.



Squadron Leader E. A. Tennant, Chief Test Pilot with Folland Aircraft Limited, is personally responsible for flight testing the *Midge*. A new wing with ailerons further inboard is now being tested.

In the Folland FO.139 *Midge* (picture) and the FO.141 *Gnat* the undercarriage doors also serve as air brakes, for which purpose they are held in half-open position.

method that would facilitate the mass production of a large fighter except an excessive use of factory space, machine tools and man-power. Naturally, the light fighter would have to be designed as a "production job" and carry the fewest accessories and instruments consistent with its efficient operation.

Question: Do you agree with the present policy of producing several different prototypes and developing them in parallel? Can we continue to do this with such machines as the English Electric P. 1 supersonic fighter?

Answer: I think we need prototypes of at least two different types of fighter and bomber under development at the same time. Whether we could afford to do this with types like the P. 1 would depend upon the number of prototypes the authorities deem it necessary to order. I doubt whether we could afford the cost of twenty prototypes of, say, two fighters in the P. 1 class; at the moment the P. 1 is in a class by itself.

Question: Do you think that the simpler Soviet designs since the war will continue to keep ahead or will they be faced with the same bottlenecks as ourselves?

Answer: The Russians will undoubtedly have the same kind of problems to contend with as we have, but they have the inestimable advantage of having unlimited man-power and money, and may therefore be able to find simpler solutions to the problems than we can with our limited research facilities, man-power and money. On the other hand, I imagine that Soviet designers probably suffer even more than we do from what I might call the "official attitude." In this country, if we disagree with the official attitude, we can at least build an aeroplane as a private venture!

Question: Will "miniaturization" of services and equipment make for (a) maintenance problems, (b) shorter working life, and (c) greater liability to failure?

Answer: I do not think that the miniaturization of services and equipment need necessarily lead to new problems or an intensification of old ones. Our light fighter has shown that certain "standard" equipment can be reduced in size and weight without loss of efficiency, and the processes which we have set in motion can, I think, be far more widely applied. In several instances, too, we have been able to make one service perform a dual function. For example, the inboard ailerons of the "Gnat" will also droop and serve as flaps; no duplication of mechanism was needed to bring this about. Likewise, the undercarriage wheel covers serve also as air brakes when the legs are partly lowered, and the same mechanism is used whether the pilot selects "air brakes" or "undercarriage down". There could be, in my opinion, a big extension of dual-functioning services.

Question: Can we provide the R. A. F. with the right fighter equipment on the present basis of things? Will they cost too much, and can they be built in quantity? If not, what are we to do?

Answer: We undoubtedly cannot equip the R. A. F. with adequate numbers of large single-seat and two-seat day and night all-weather fighters, and maintain them. To remedy the present state of affairs we must cease to think only of the target defence problems which have led to the present appalling complication. The defence of London and even the defence of England are not the only problems; there are others overseas to which we are not giving sufficient attention. In trying to solve home defence problems, I think we are tending to put into the aeroplane much equipment which should be on the ground. If fewer aids were airborne we could make our fighters both lighter and smaller, thereby simplifying their design, construction and maintenance, cheapening them and increasing their flexibility.

The swept wings in the *Midge* (picture; with outboard ailerons) and the *Gnat* (with inboard ailerons) are in one piece. They weigh a bare 660 lbs. complete.

THE FOLLAND "GNAT"

The first of the very light-weight jet fighters is the Folland **Gnat** which is due to fly in prototype form this summer, powered by a Bristol **Orpheus** turbojet. The development prototype for the **Gnat**, the A.S. **Viper**-powered FO.139 **Midge**, was demonstrated at the 1954 Farnborough Display.

The genesis of the **Gnat** dates back to 1951, when the Royal Air Force was ordering new swept-wing fighters. In its original form, the **Gnat** was a somewhat different machine with a lower performance. It was designed around the Bristol BE.22 **Saturn** light-weight engine of 3,750 lbs. thrust which was originally developed to meet a Ministry programme for an expendable turbojet to power a Martin B-61 **Matador**-type missile.

The missile and the engine were cancelled and with them the hope, then, of an R.A.F. order for the **Gnat.** Mr. Petter, managing director of Folland Aircraft Ltd., continued to develop the machine as a private venture. Impressed by the potentialities of the machine and light fighter projects in Europe generally, the Bristol Aeroplane Co. Ltd. then resumed work on light-weight turbojets at their own expense and produced designs for a new and more powerful unit, the **Orpheus**, intended in developed form to deliver 4,850 lb. thrust. The **Orpheus** also has the advantage of being designed from the outset for "long-life" applications. Bristols are reported to have spent £1,500,000 on the **Orpheus** to date. The first bench run was made on December 17th, 1954, though a number of the components had been tested earlier.

The FO.141 **Gnat** itself is a small single seat pure interceptor or tactical fighter with a span of 20ft. 8ins., a length of 28ft. 9ins. and a height of 8ft. 9ins. Throughout, simplicity has been the watchword and pressed sheet metal forms many of the parts. There is only one forging and this acts as rear gun attachment, wing support and undercarriage locating point.

Maximum strength has been built into the 40°-swept-wing of 8% thickness-chord ratio which is built in one piece and has separate internal stiffeners. Hydraulics and electrics have been reduced to their simplest form; a typical example of the integration of various requirements is in the air brakes which form the undercarriage doors, the undercarriage being fully lowered by a single jack for landing or put into an intermediate position for air brake operation. Large inboard ailerons are carried, which, when dropped, serve as flaps. A power-operated all-flying low-set tailplane is fitted.

The Bristol **Orpheus** is housed in the rear fuselage; access to it is gained by removing the rear fuselage section. The **Orpheus** has an overall diameter of 32 ins., a length of 97 ins., and a dry weight of only 850 lbs. On later production **Gnats** the Bristol simplified reheat system would be incorporated. This weighs only about 90 lbs. but gives up to 40% increase in thrust. With development the **Orpheus** can be expected to go well into the 5,000 lbs. thrust class dry, and over 7,000 lbs. with reheat. A specific consumption of 1.1 lbs./lbt./hr. at 3,900 lbs. thrust has been quoted for the unit, a figure that will be reduced to 0.97 lbs./lbt./hr. in the developed version. All internal fuel on the **Gnat** is contained in fuselage tanks, and these may be supplemented by external drop tanks.

Armament of the **Gnat** is basically two 30-mm high velocity Aden guns fitted in the fuselage sides and firing through the intake lips. In order to avoid at the outset compressor stalling troubles such as were encountered on the **Swift** and the **Hunter** (in which the muzzle blast causes surging in the compressor at certain altitudes), experiments are being made with deflector plates by the muzzles. Two air-to-air guided missiles can be carried under the wings. For tactical work the **Gnat** will be able to carry two 500 lbs. bombs, napalm bombs, or twelve 3 ins. rocket projectiles.

Comprehensive internal equipment will include 10-channel VHF with standby, I.F.F., light-weight DME, and a radar range gunsight. The cockpit is pressurized and the pilot will use a Folland/SAAB light-weight fully automatic ejection seat.

Full weights and performance figures for the **Gnat** have not been made available yet, but some figures have been mentioned. Equipped all-up weight will be just over 6,000 lbs. Performance with the **Orpheus** will give a top speed of Mach 1.2 and a service ceiling of over 50,000 ft. Endurance is one hour and time to 40,000 ft. 5 minutes.

Two Rôles for one Turbojet

THE VIPER — SHORT-LIFE AND LONG-LIFE

BY H. DENAMUR, AVIONS MARCEL DASSAULT, PARIS

The *Viper,* designed by Armstrong Siddeley Motors in 1950–51, was the first successful attempt to develop a so-called "expendable" turbojet. The idea of a short-life engine had been in the air for some time and had originally been born of a reaction against the structural complexity and excessive cost of engines built to conventional specifications. A careful re-examination of the problem could naturally be based only on a revision of the usual operational requirements for both aircraft and their power plant.

The first convention tackled was operating time between overhauls. Long operating periods are normally one of the first demands of the operator, since they determine the amount of personnel and spares required to ensure adequate maintenance.

However, though a long running time between overhauls is of considerable influence in peacetime on the strength and cost of an air force, its value in wartime is open to question. The average life of an aircraft during World War II was only several tens of hours, and was terminated by destruction in battle, which—statistically speaking—occurred long before mechanical failure due to wear and tear.

This is one of the numerous dilemmas encountered in the creation of a military force whose possible employment in wartime would be under quite different, or even contradictory, conditions from those of maintaining it economically in times of peace or "cold war".

In the case of the *Viper* the demand for the longest possible life was abandoned, and the British Ministry of Supply fixed a target of 10 hours of operation between overhauls. Here a brief comment on the term "short-life" is opportune. There was never any question of arbitrarily scrapping every engine after ten running hours. No reputable engineer would ever consider an engine capable of running perfectly for ten hours, after which time all its components without exception would give out. Whether the life required is long or short, it is always determined by a small number of critical parts. Whereas, however, in a long-life engine, the critical parts are always the same ones, wear is much more unpredictable in a short-life model and may affect varying parts of the engine, which has purposely been designed, produced and assembled on the simplest possible lines. Hence "expendability" means simply the withdrawal of the whole engine after a given period and the recovery of suitable parts for re-use. In other words, what it amounts to is a systematic "cannibalization".

The general advantages of such a system are obvious. Firstly, the raw materials used in the manufacture of the engine can be cheap and for the most part "non-strategic". The whole structure can be of the utmost economic simplicity compatible with maintenance of the engine's indispensable thermodynamic qualities. Squadron overhauls and maintenance can be entirely dispensed with, along with the costly organization they require. All that is needed is a standard system of replacing complete engines, backed by a standard system of supplying these engines to the squadrons. Manufacturers would then have to have recovery lines parallel to their assembly lines.

Admittedly the full advantages of the plan become apparent only in wartime. But, after all, these are the conditions ultimately envisaged in planning all armament.

The Viper AS.V.3

To return to the *Viper,* the original programme covered a power plant for a pilotless target aircraft, namely the Australian-built *Jindivik.* In addition to being expendable, it therefore could incorporate other major simplifications:

— lower structural strength, as conditions of flight do not impose high stress;

— elimination of complicated regulation, since engine speed remains constant after launching.

Such was the specification which led to the *Viper AS. V. 3,* with a weight of 365 lbs. and a thrust of 1,630 lbs. at 13,400 r.p.m. Despite the low compression ratio chosen (3.5), preference was given to an axial compressor in order to reduce frontal area.

The rotating part consists of a seven-stage compressor, a shaft and a single turbine wheel. It is mounted on three bearings with a "complete loss" oil system. The combustion chamber is the usual one in Armstrong Siddeley engines, namely annular with fuel injection by vaporization. Other special features of the design are:

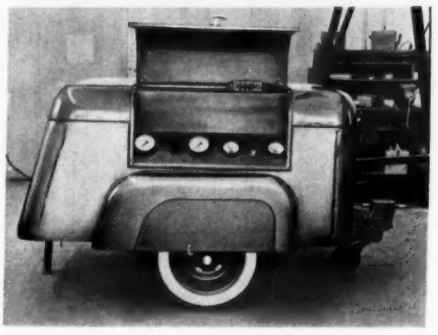
— The compressor stator blades are cut from shaped constant-profile steel tube

AS.V.3 short-life version of the Armstrong Siddeley *Viper,* as used in the Australian *Jindivik Mk.2* target aircraft.

and brazed at the ends into rings fixed in the housing.

— The turbine stator blades are also cut from constant profile tubes; they are fitted into cut-outs in two rings and held in position, with suitable play, by radial rings.

— Starting is by the injection of compressed air at 142 p.s.i. on to the turbine, thus reducing the weight of airborne equipment to the minimum.



This jeep trailer with six normal compressed air flasks of 2,135 p.s.i. is used to start the MD.30 and AS.V.5. The compressed air suffices for 6 to 10 starts.

From the short-life to the long-life Viper

The good results obtained with the short-life *Viper* encouraged the makers, backed by the Ministry of Supply, to develop from it a long-life version, to meet the normal specifications for a turbojet, and with the maximum possible endurance.

This was by no means a step backwards or an admission that the short-life formula was a failure. The latter is still fully valid and has since attracted other manufacturers. But, as has already been stated, the principle of "expendability" only comes fully into its own in time of war—apart from its limited use in pilotless target aircraft. The *Viper AS. V. 5* was therefore designed to have the longest possible endurance, for installation in a fighter, where it would have to be of sufficient structural strength to withstand all phases of high-performance flight and be capable of the rapid changes in speeds associated with these manoeuvres.

The transformation of the AS. V. 3 into the AS. V. 5 was therefore characterized by:

— an improvement in the quality of the structural materials to give longer life;

— strengthening of the structure;

— inclusion of a fuel regulation system to permit of high altitude flight at all engine speeds between idling and maximum power and of rapid changes in speed within this range.

The similarity between the *Viper* and the *Sapphire*, already apparent in the short-life version, is even more marked in the long-life *Viper*. For example, the fuel regulation system in the *Viper* is identical with that in the *Sapphire*. The combustion chambers and central housings bear striking resemblances. All in all, it would not be an exaggeration to describe the *Viper* as a miniaturized *Sapphire*.

Nevertheless, the AS. V. 5 has taken over from its short-life predecessor a great simplicity of line which makes of it a particularly robust engine. Progress was also very rapid, and it received its Ministry of Supply certificate in September 1954.

The Dassault Viper MD.30

Avions Marcel Dassault acquired the licence for the *Viper* in March 1953 and immediately began production. At the moment only the long-life AS. V. 5 version is being produced, for installation in the firm's own airframes under the programmes for light interceptors or tactical aircraft.

The Dassault design office has made a number of modifications to the AS. V. 5, to adapt it to its airframes. For example, the airframe designers asked for a symmetrical arrangement of accessories to enable two *Vipers* to be combined to form a dual engine. The pre-war system of duplicating parts in "symmetrical" engines had, of course, to be avoided. But by an ingenious design of the front casing it is possible to place the accessories box on either the left or the right as desired, so that a left-hand engine can rapidly be converted into a right-hand one or vice versa without adding new parts.

Incidentally, the compressor housing, which is of aluminium alloy in the AS. V. 5, is of magnesium-zirconium alloy in the MD. 30.

Finally Dassault has also designed an afterburner for the *Viper*, containing an "eyelid" operated by pneumatic jacks. Fuel is injected in front of the turbine, as part of an automatic sequence. Flight tests are now being made in a *Languedoc* flying test bed to ascertain the afterburner's high altitude qualities.

At present it gives an increase of 32% in static thrust at sea level, which raises the AS. V. 5's thrust to about 2,200 lbs. Total specific consumption is 2.4 lbs./lbt. h. Weight of the afterburner plus accessories is 165 lbs.

*

The *Viper* is fitted, or is to be fitted shortly, in a number of aircraft for various missions. In Britain it powers the Folland *Midge*, the Hunting Percival *Jet Provost* trainer and other projects by Avro, Saunders-Roe etc. In France, the MD. 550 and SO. 9050 light interceptors use it, as well as a number of ground attack projects. Finally in Australia, as already mentioned, the *Jindivik Mk. 2* target aircraft is fitted with a short-life *Viper*.

The *Viper* has already run several thousand hours and will add considerably to this number during 1955.

The production of two versions of a turbojet with the same thermodynamic design, one short-life and one long-life, would seem to offer a solution to the thorny problem of creating an air force that will be efficient in combat from the limited funds available in peacetime.

MD.30 long-life version of the *Viper* turbojet with the afterburner designed by Avions Marcel Dassault. The exit area of the greatly enlarged jet pipe can be varied by two "eyelids" operated by pneumatic jacks (visible top and bottom). Fuel for the afterburner is injected in front of the turbine.

Miniaturized Avionics

BY K. M. MILLER, ASSISTANT GENERAL MANAGER
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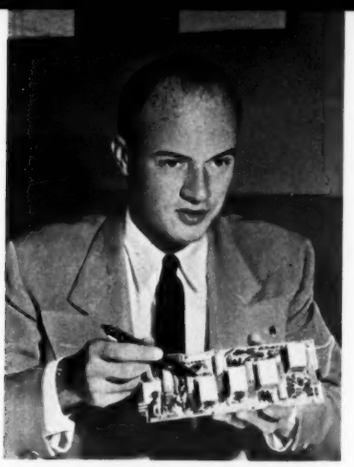
SANTA MONICA, CALIFORNIA, U. S. A.



The author with a miniaturized R/T set.

The modern aircraft's requirement for electronic devices to fulfill the needs of today's flight techniques has produced many "scaled down" versions of basic electronic equipments. In addition, the need to create new devices to eliminate a maximum number of aborted missions has accelerated the advancement of the art of miniaturizing electronic packages. The following describes a modicum of the efforts being exerted by the engineering staff of the research and development division of one American electronics company.

*

A brief glance into the interior of a modern aircraft is all that is required to present the case of a program of miniaturization of its populous electronic contents. Unfortunately, a review of the efforts along these lines reveals little that is being accomplished in the area of standardization. Until recently, the electronic packaging engineer felt absolutely no restraint to giving birth to an idea which would create a device that was outstanding in that no one had ever before created a "black box" shaped like his.

The physical configuration of miniaturized equipments will probably follow the general pattern which has been characteristic of the so called "standard" electronic packages. This means that we shall continue to "custom" design for special applications, particularly in the missile field. It is unfortunate that greater consideration is frequently not forthcoming at the time of initial planning of the overall vehicle and its components. In the airline field we find that some airlines are seeking ¼ ATR units to replace equipment now packaged in the ½ ATR configuration. The weight savings follow the volumetric reproductions at almost a linear rate in airborne electronic equipment.

Reliability

On the opposite side of the ledger we find that much has been done to advance the state of the art. Component manufacturers have been engaged in an aggressively competitive race to outshine each other in the process of producing material that is diminutive and dependable. It is significant to note that in most instances, producing a smaller component will increase its reliability factor. This occurs particularly when we witness the results of vibration and impact shock tests. To exemplify, quartz crystals, used to create stable oscillation, have been markedly reduced in size. Figure 1 shows the comparison in physical size of a large crystal which has been popular until recently and its modern counterpart. The small crystals can be seen in an actual application in Figure 2. Here twenty crystals are nestled directly on a switch wafer used in the Model LTR-800, an 800 channel VHF receiver and transmitter. These small units, typical of other "scaled down" components, actually provide greater reliability as a result of their increased natural resonant frequency.

The application of etched wiring to electronic assemblies has proven to be a major contribution to increasing their reliability when exposed to environments of severe vibration and mechanical shock. The employment of the process can be observed in the figures. The automatic rudder control (ARCON) amplifier is an excellent example of this method which has yielded uniformity in wiring quality and accomplished excellent compactness. *

An obvious disadvantage of high density electronic packaging is the potential problem of excessive internal temperature rise. Special devices can be employed to conduct the internally generated heat to the outer shell or housing for normal radiation into the surrounding atmosphere.

Packaging

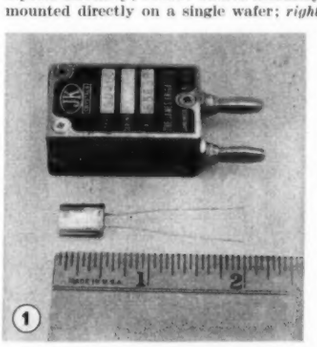
Perhaps a brief review of designs which contain some of these techniques will help illustrate the practical aspects of miniaturization.

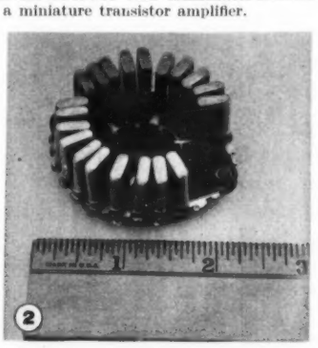
To provide a high reliability and ultra compact standby VHF communications transmitter, receiver and power supply, the unit shown in Figure 4 was designed. The receiver performance and transmitter power output exceeds the specifications of many equipments whose comparative physical volume and weight are much greater. This device employs etched circuits, sub-miniature tubes and a recently developed 400 cps vibrator in the power supply. This latter feature permits the application of associated power supply components which are volumetrically approximately one-fourth the size of similar components used with conventional 115 cps vibrators.

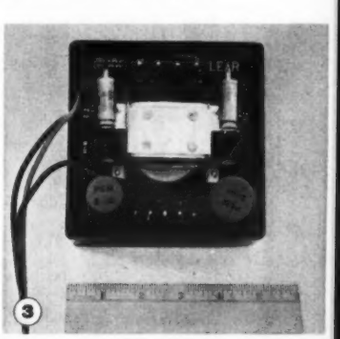
Transistors are beginning to cut a wide swath in airborne electronic plans. We can

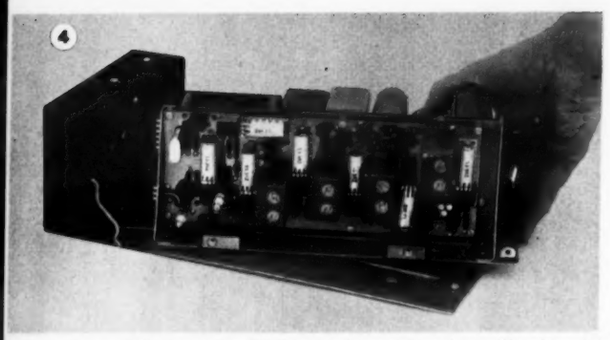
* Cf. *Interavia* No. 1, 1955, p. 125.

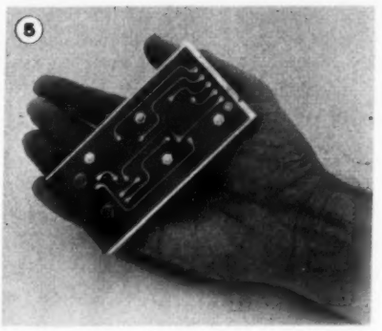
Miniaturizing the components of high frequency equipment. Left: comparison of a modern and an older type of quartz crystal assembly; *centre:* switch assembly in the LTR-800 VHF transmitter-receiver with 20 sub-miniature crystals mounted directly on a single wafer; *right;* a miniature transistor amplifier.











Left: a standby VHF transmitter and receiver with self-contained power supply; *right:* an etched circuit 10-Watt output audio power amplifier.

see two power transistors and etched circuitry combined to produce a 2 watt output loud speaker amplifier in Figure 3. This device amplifies normal head audio output from an airborne receiver to an audio level which energizes the loud speaker. Also in Figure 5 we see two transistors and etched circuitry which provides 10 watts of audio output for speaker operation in aircraft where a high ambient noise level exists.

Conclusion

It can be shown that the present state of the art in the field of miniaturization is restricted by the following:

— A limited quantity of reliable components exists.

— Miniature components are frequently prohibitively expensive, thereby limiting their use to special military applications.

— Severe high density packaging presents major cooling problems. Particularly true in the missile field when the equipment is exposed to atmospheric pressure and temperature.

On the second half of our balance we find several major advantages. Amongst these are the following:

— Usually higher reliability, especially in the area of vibration and shock.

— Greater reliability by elimination or reduction of remote control functions.

— A major saving in weight.

We will always find ourselves limited by such fundamental items as the size of the human hand. This problem is aggravated by this hand wearing a glove. Control knobs can only be made small enough to retain ease in operation. This means that the size of the gloved hand dictates our control panel knob density.

The art of miniaturization has barely been exploited. It is mainly paced by the rate of component development. This in turn is controlled to a great extent by the rate of development of the basic materials which are needed to provide sub-miniature components.

The missile and manned airborne vehicles have a common problem; how can more electronic equipment be installed and concurrently provide greater reliability? The progress toward the achievement of this end during the past decade has been significant. However, the next decade will see many basic ideas reduced to practice and progress will increase by several orders of magnitude.

"Television Flight" by 1958?

TWO TV SCREENS WILL REPLACE ALL INSTRUMENT DIALS

BY SCHOLER BANGS, LOS ANGELES

Interavia's U.S. Editor reports below on a very ambitious programme for simplifying flying, especially in instrument weather. The programme, worked out jointly by Douglas Aircraft and the U.S. Navy, is based on a new small, flat television screen developed at Willys Motors' electronics laboratories. A special version of this screen is transparent, so that direct vision through the screen is possible as well as the television picture. No details on how the television picture is produced, are available, however, though it is clear that the system is in no way related to the Teleran system in which the television image is transmitted to the aircraft from the ground. On the contrary, the picture of the ground ahead must be obtained by equipment in the aircraft itself, probably by reflected radio waves of very high frequency or direct infra-red rays. It will be recalled here that a SHF system, known as "radio vision", was under development at the end of the war; with it the outline of a warship, for example, could be clearly discerned, down to details of masts and funnels.

A radical change in cockpit "scenery" is in prospect for all future aircraft, civil as well as military, if all goes well with a "by-product" of the United States light-weight combat airplane program.

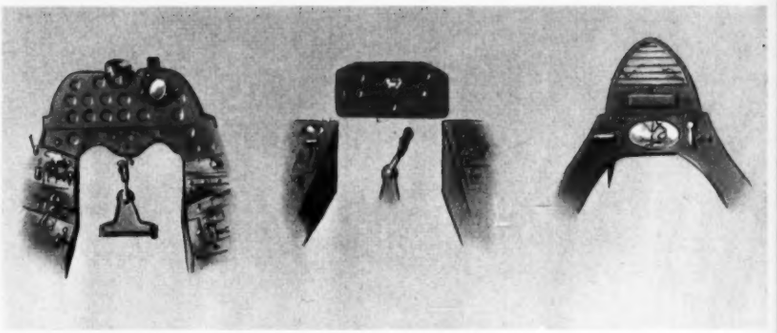
Today's confusing landscape of glowing dials and dancing indicator needles will have vanished. A few years hence, the pilot of your jet transport should be able to settle down to a comforting Visual Flight Reference ride when he goes "on instruments".

Through storm and dark of night, two television screens will show him the landscape ahead, the terrain below, where he is at a given moment, and how far he can fly in any given direction on the fuel remaining in his tanks.

Douglas mock-up of a new television cockpit for light-weight single-seat combat aircraft.

The mockup for such a dial-free cockpit already is in existence in Douglas Aircraft Company's new El Segundo Division engineering building, and is tailored to the structure of an A4D "Skyhawk" light-weight bomber. The test flight prototype should be airborne, for U. S. Navy testing, in 1958.

Transparent television screen made by Willys Motors' Electronic Division, Palo Alto, California. A thin phosphor screen, which only slightly reduces transparency, is sandwiched in a hermetically sealed space between two rectangular glass plates. An electron gun, not shown in the picture, injects a beam horizontally along the lower edge of the tube. The beam is deflected upwards by a row of deflection plates resembling piano keys along the edge of the tube and projected on to the phosphor screen by a series of horizontal deflection plates. By changing the voltages on the deflection plates the electron beam can be made to scan the whole phosphor screen, thus producing the television picture.



Progressive simplification of the instrument panel of single-seat combat aircraft under the joint Douglas-U.S. Navy programme. – Left to right: present "standard" version; simplified interim version; future arrangement with two television screens and miniaturized levers for aircraft control (right), engine and automatic trimming (left).

Navy-sponsored, the cockpit has been under secret development for two years by a select group appointed by E. H. Heinemann, Douglas El Segundo Division's Chief Engineer, and headed by A. M. Mayo, chief of the Division's Equipment and Interiors Engineering Section.

It is no ivory tower undertaking.

No less than twenty U.S. instrument companies have been taken in as active participants, and some two hundred others have asked for information which will prepare them to build whatever is required when production bids are called.

Acting under a top priority, Navy has called in all U.S. aircraft manufacturers for detailed briefing on the program. U.S. Air Force cooperation is being given, with direct assistance coming from Air Research and Development Command and Wright Air Development Center.

Details of the project still are under such high security classification that it is impossible to disclose the manner in which in the space of a few years, with the flight date only three years away, Navy, Douglas and the instrument industry will have been able to get rid of instrument dials, convert the bulk of their intelligence into automatic functions, and leave the pilot free to simply watch where he is going.

Navy and Douglas spokesmen agree, however, that the problems involved have not proved insurmountable, and they cite the mockup cockpit as fairly indicative of the appearance of the forthcoming flight article.

In the A4D mockup the pilot finds himself seated at a waist-high "office desk", the top of which curves back on either side as an arm rest as he operates with his left hand a "go handle" which combines the throttle with integrated trim settings, and with his right a stubby ball-socketed "stick". Beneath the "desk" his feet find their way to conventional rudder pedals.

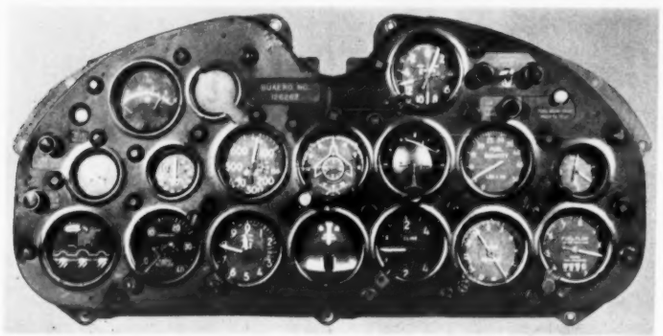
Flush-mounted in the desk top, and viewed with an easy downward glance, is a circular television screen approx. 8 ins. in diameter upon which will appear, reduced to scale and giving the effect of extreme altitude, a slowly-moving map of the terrain over which he is flying. The perimeter of the circle displays bearing information. A dot at the center of the screen indicates his airplane's momentary position.

At the start of his flight the entire area of the television screen may be representative, with relation to the map, of the range of flight at his disposal. However, as fuel is used there will appear on the screen a slowly-shrinking inner circle which will show on the moving terrain map the range of flight remaining, down to the moment when the circle shrinks and finally becomes one with the airplane dot at the center of the screen . . . no fuel!

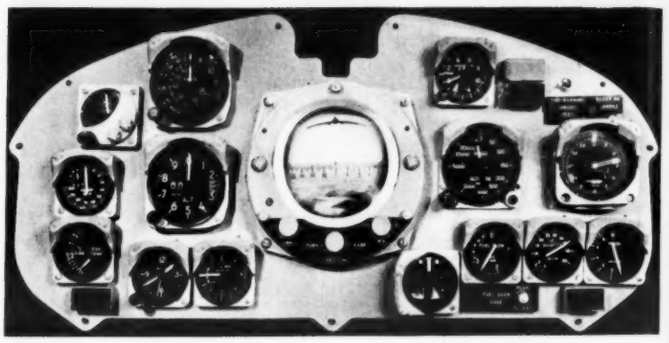
The range circle without doubt will be an endless source of fascination to the pilot in that it will present a constantly changing deformation, its perimeter varying from a perfect circle as data on head, tail or cross winds and speed of the airplane are fed into a computer which dictates the size and shape of the range circle projected upon the screen.

Directly ahead of the pilot's face, mounted vertically upon his "desk" is a flat glass "window" through which the landscape within his vision, and horizon, will be seen in normal clear-weather flight. "On instruments" the window becomes a flat-plate television screen, presenting what Navy and Douglas representatives describe variously as a "facsimile landscape" or as a "showing of enough visual clues to permit a practical job of flying to be accomplished".

The two television screens, the only "normal instruments" in the Douglas mock-up, are in the pilot's immediate field of view. The circular screen displays: 1 – the aircraft's position (centre of screen) in relation to the map of the terrain flown over; 2 – course steered (graduated ring round screen); 3 – the remaining range in all directions (small circle about the centre); 5 – fuel reserve. – The semi-circular "advance orientation" screen displays not only a picture of the ground ahead but also; 6 – aircraft speed; 7 – altitude; 8 – pitch and bank attitude (as in artificial horizon). – The pilot operates the "speed lever" with his left hand and the "control column" with his right. Behind the vertical screen is the cabin's windshield.



Overloaded instrument panel in a U.S. Navy single-seat jet combat aircraft. The double-pointed altimeter (third instrument from left, bottom row) is particularly difficult to read. Air speed indicator (above the altimeter) and Mach meter (covered) are separate, as are also artificial horizon and directional gyro indicator.



The same instrument panel after simplification: angle of attack indicator (top left); combined air speed indicator and Mach meter (next to the right); artificial horizon with gyrosyn compass rose; bearing and distance-to-home indicator (top, extreme right). Note the grouping of the instruments into blocks.

Scattered about the desktop of the mockup cockpit are a surprisingly reduced number of inevitable toggle switches; for the most part master controls giving "off" and "on" signals to several combinations of automatic instrument systems supplying actuating information to the television screens and aircraft operational devices.

As a safeguard in the event of catastrophic failure of the television systems, the flight prototype—and probably ensuing production models of the cockpit as well—will carry a minimum number of highly miniaturized and refined "old fashion" dial instruments, their faces very likely concealed by a flip-up cover when their use is not required. They probably will give the pilot his direction indication, altitude, airplane attitude and speed.

Intent upon avoiding needless cluttering of the "office" with obsolescent dials, the Douglas project chief, Mayo, says:

"We probably will give the pilot just enough independent instruments to get him home if things are not too tough. The independent instrumentation will not be intended to do an operational job."

It perhaps is not wholly to the credit of this Navy-Douglas project to refer to it as a "by-product" of the light-weight combat aircraft trend.

However, there can be no question that the light-weight philosophy, suggesting ever-increasing speed and ever-decreasing space available for the multiple "gadgets of flight", presented an open invitation to engineers, psychologists and physiologists who previously could only speculate on the approach of a showdown in the battle of Man vs. Instruments.

With no fanfare and a strong inclination toward preliminary obscurity of terminal objectives, Navy created a "Program for Development of Integrated Presentation of Flight Information". Program backers in Bureau of Aeronautics and Office of Naval Research took a fresh look at what was happening to airplane speeds, altitudes and mounting confusion of controls and instruments. In contrast, they found in the cockpit the same, unchanged and unchangeable human pilot of the wood-and-fabric aircraft of World War I... one head, two eyes, two hands, two feet.

"We could foresee", one Navy spokesman explained, "an era of terrific speed in which the pilot might ask 'Where am I?' and obtain an answer to the question 'Where was I?'."

Human responses could not keep up with the instruments, and very often the instruments themselves could not keep up with the airplane.

The move toward integration and miniaturization of varied components of projected light-weight aircraft gave both moral support and objectivity to the planners of a "new look" cockpit which might enable today's human pilot to keep up with tomorrow's airplane.

Experimentally, standardized instruments were redesigned for simplification, improved performance, reduction of size to fit smaller control panel allowances, and integration with companion instruments where possible.

In an initial approach the Navy program effected a 10 percent reduction in the number of instruments confronting the pilot of a standard fighter. In a second step of simplification another 10 percent reduction in the instrument count was scored. By the time the A4D was ready for flight the number of instruments originally contemplated for the aircraft had been reduced by one third.

Currently flying in Grumman F9F-6 *Cougar* naval fighters and a TD-2 are Navy "interim" instrument panels carrying only five basic instruments: angle of attack indicator; combined Mach and air speed meter; counter-pointer altimeter; bearing and distance-to-home indicator and horizon indicator. All are specially designed for quick reading and minimizing human error in visual acceptance of their information. It had been found, for example, that the old-style threepoint altimeter dial required a reading time of 7.7 seconds and that 11.7 percent of readings involved interpretation errors of 1,000 ft. or more. In contrast, the new counter-pointer altimeter face can be read in 1.7 seconds and with potentially serious errors of interpretation reduced to only .7 percent of readings.

Other refinements in the new Navy-Douglas cockpit are reflected in movement of the pilot into closer proximity to the two basic instruments he will read, and by integrating previously separated power controls with the movement of the single throttle lever or "go handle".

Movement of the pilot toward his instruments is achieved largely by removal of the conventional control column from its historic mounting on the floor between the pilot's legs and placing its miniaturized counterpart on the "flight desk" to the right of the terrain map viewer.

In the mockup, the integrated throttle lever has a long path of travel which permits clear separation of successive positions identified by boldly-lettered descriptives. The settings are interpreted in functions of flight and read, commencing with the fully-retarded position of the handle: Glide—Max. Efficiency; Glide—Normal; Approach; Cruise—Max. Efficiency; Cruise—Hi Speed; Climb—Max. Efficiency; Climb—Hi Speed; Takeoff—Normal, and (fully advanced) Takeoff—Max.

Navy officers who described the program at the first showing of the cockpit mockup to West Coast aviation writers, gave varied estimates of anticipated achievement:

"We want the pilot to know where the mountain peak is—in time to do something about it."

"We're designing for warm bodies."

"We're trying to spell out the end of the superman pilot, so that the natural man can fly again."

The West-East No-Mans-Land in Europe*

Whatever the outcome of the international tug-of-war for Germany, or more exactly for the West German Federal Republic, may be, how and when the ratification of Western European Union will be accomplished . . . it may conservatively be assumed that West Germany will get its sovereignty and hence its freedom to arm by the summer of 1955. However, those circles outside Germany which believe that it will then suffice merely to push a button in order to create a German arms industry, German fighting forces or a Lufthansa on the old scale are mistaken.

How does this complicated situation look from inside Germany at the beginning of 1955, and what are the next developments likely to be?

*

The arms industry

A visitor to the hotels of West Germany—say in Stuttgart, Frankfurt, Cologne or Hamburg—will come across representatives of the arms industries of all Western European countries and of the United States. They are there to call on the Government offices in Bonn and Coblenz, or the heads of West German industry, and are not holding back with their bids. The future German forces are being offered large quantities of aircraft with full equipment, or even licences for their production: admittedly, the types discussed are not always the very latest, but Germany might provide a unique opportunity of keeping production lines going which otherwise might have to close down. Industrial representatives, officers and officials in Bonn and Coblenz listen politely to these offers . . . and think of their own problems. The Paris Treaties have not yet been ratified, let alone applied in detail, no drafts for a future German defence legislation have yet been laid before Parliament, the Federal Minister of Finance has not yet released any funds, the Federal Minister of Economics has no more than roughly outlined the programmes, and . . . the much-discussed "Blank Office", the nucleus of a future German defence ministry, bears the stamp of a provisional organization.

It would be wrong to assume that German industry is unreservedly enthusiastic about the production of arms. With the possible exception of the West German railway rolling stock industry, it is already working to full capacity and at the moment is doing extremely well! It has still by no means caught up with the constantly increasing demands of a domestic market starved for consumer goods during the war and post-war years, and is highly active in the export field. To take one example, a major firm like Daimler-Benz, of Stuttgart, is said to have delivered vehicles to a value of more than 1,000,000,000 Marks (over $200,000,000) in 1954; it has had to rebuild and re-equip bombed plants, and could not find room overnight to undertake aircraft engine production, for example, in its present facilities without wearisome preparations. The same applies on a smaller scale to B.M.W., the Volkswagen works and others.

Theodor Blank, who bears the provisional title of "Representative of the Federal Chancellor for Questions concerned with the Increase in Allied Troops". The "Blank Office" will be expanded into a defence ministry when Germany's sovereignty is restored.

Lieutenant General (retd.) Adolf Heusinger, head of Section II of the Blank Office, the only ex-officer among the four section heads.

Dr. Ing. Fritz Nallinger, Board member and Technical Director of Daimler-Benz A.G., at one time Germany's leading aircraft engine manufacturers.

Under-Secretary of State Professor Leo Brandt energetically supported the revival of German aeronautical research after the war.

There is thus no keen interest today in arms production. Industry is making a good living, and its leaders are by no means certain what the term "controlled sovereignty"—or the control of arms economy—means for them. As long as they turn out peacetime goods, such as cars, they are accountable to nobody. But if they went over to the production of military equipment, they might perhaps tomorrow find themselves surrounded by a whole posse of "diplomats", each trying to put over his own very special point of view.

Then there is another point: Professor Ludwig Erhard, the Federal Minister of Economics, made some very plain statements in mid-January, which took the gilt off the gingerbread even before the latter was baked: . . . "The evil of 1936 will not be repeated . . . we shall organize arms production on the same economic principles as our other reconstruction . . . Standard of living and currency will not be affected . . . No government arms factories on the 1936 model . . . International exchange of military requirements on free market principles, no international arms cartels." The Minister particularly stressed that West Germany would buy from abroad any weapons or equipment it could not produce more cheaply itself, and would count on exporting such arms which it could produce on a competitive basis.—In general terms this means that the armament industry must not reckon with subsidies as in the Third Reich, on inflated prices etc. It must run its own risks and put its shoulder to the wheel. It remains to be seen whether Erhard will be able to carry through this programme.

It is easy to see why, under such conditions, an industrialist should hesitate to accept risks and stretch his working capital just to please Herr Blank. When French Premier Mendès-France came out at the beginning of January 1955 with the idea of a West European arms pool, with his eye on West Germany, he appears to have been calculating on a partner who does not yet exist. And British or Ameri-

* Cf. *Interavia* No. 11, 1954, p. 739 "Germany Reenters the Arena", and No. 10, 1954, p. 692 etc. "The Breakdown of EDC and After . . ."

can businessmen who are getting in early with firm offers must also be prepared to wait until the partner is in a position to act, and even then allow for the fact that the future purchaser will have to be careful with the money he spends.

The solution would appear to be that once the Blank Office is expanded into a defence ministry, it will probably have two under-secretariats, one for purely military questions, the other for the industrial and economic side of rearmament.

If it is assumed conservatively that the preliminaries are completed in the summer of 1955, an under-secretariat for armament production may be ready for action by the end of the year.

*

The future defence forces

Here again it would be an error to assume that land, sea and air forces—the term "Wehrmacht" is assiduously avoided—can come into being at the word "go". Here too it can be said that the "evil of 1935" will not be repeated. In those days Hitler and Göring could really push the fateful button, as General Seeckt had left them a first-class framework in the Hundred-Thousand Man army allowed under the Treaty of Versailles. Today, Germany has to rebuild from scratch.

There is no shortage of generals or of colonels who, but for the interruption of the past ten years, would long ago have become generals. But majors, captains and lieutenants are, to put it mildly, a trifle elderly. The gap could, of course, be bridged by volunteers, and in time conscription will produce adequate numbers for twelve divisions. But . . . all these recruits must first be trained. Even if—at an optimistic guess—a conscription law were passed in the winter of 1955–56, it would take some considerable time after that to set up twelve mechanized divisions, let alone air units as well. As regards the latter, another two years would probably be needed before the first squadrons were operational.

Now there are certain peculiarities in the hierarchy of the Blank Office which are apparently due to the desire that its structure should conform to democratic principles of administration. The permanent representative of "Security Official Blank" is not a general but a civil servant, in the person of Ministerial Director Wolfgang Holtz. Under him there are four sections, of which only section II is headed by a former general, namely Lieutenant-General Adolf Heusinger. An "outstation" in Coblenz is engaged in preparatory organizational work for a future procurement office. Its head is Dr. Rentrup. Attached to this office is a technical sub-section, whose task is to select the equipment for the armed services, including the air force, in agreement with the military members of Blank's organization. It is headed by former Lieutenant-General W. Vorwald. It remains to be seen whether this new-style organization can meet the wishes of the "consumer", i. e., the fighting units and the authorities responsible for expenditure.

It is an open secret that there is a certain amount of disagreement on this point as far as the air forces are concerned. The responsible officers of the former Luftwaffe make no attempt to conceal their fears that they may be overruled by the civil authorities or the army. The officers responsible for the future air force are at the moment not in the least interested in combat aircraft. In their view all that is needed to begin with, during the build-up period, is trainers, which should first be purchased from abroad and later built under licence. Combat aircraft should be bought when training is complete, and not before. Any other course of action would mean buying equipment that would be ready for the scrap heap in two years. This, incidentally, is yet another reason why the future German aircraft industry will have to mark time for a while.

At the beginning of 1955 it looked as if, in order to arrive as rapidly as possible at independent and successful planning, certain hopes were being placed in former Luftwaffe Lieutenant-General Adolf Galland. Contrary to expectations, however, Galland's visit to Germany will probably come to an end shortly. He is returning to Argentina, which he left a few weeks ago to sign an agency agreement for South America with a German firm. Who will be the next candidate?

This section may be closed with a little story from Bonn. An unnamed civil servant, discussing the question of finding future officers, is reported to have said that "there would be plenty of them available at the labour exchanges . . ." Apart from the fact that this is probably not true, as competent officers have long since been absorbed by industry and commerce, such a remark—if indeed it had been made—would leave behind a bad flavour, since it is contrary to the esteem in which the officers corps of both West and East are held.

*

Air transport

Of all German aviation activities, air transport will be the first to take shape, though on a much more modest level than the Federal Transport Minister envisaged a year ago or many foreign airlines feared until quite recently.

The Deutsche Lufthansa is at present undercapitalized. It will have a fleet of fifteen aircraft, of which four twin-engined Convair 340's have already been delivered for medium-stage services in Europe. Four four-engined Lockheed L-1049 *Super Constellations* will be ready for use in the summer of 1955 for overseas services, and four more may perhaps be delivered on a priority basis in 1956. These twelve machines are supplemented by an old Douglas DC-3 and two Swedish SAAB *Safir* trainers. This is all for the present.

But for a good many months the aircraft captain's seat will be occupied by British and American pilots, until the young German pilots trained in Switzerland, Holland, Britain or the United States have sufficient experience to operate the Lufthansa as a really "national" airline. Other flight personnel—particularly hostesses—will undoubtedly be available, and another point on the credit side is that the ground services should function satisfactorily.

Such is the outcome of four years' planning by the Federal Transport Ministry's Aviation Department and the Lufthansa Board, for which, according to rumour, no head has yet been found.

*

Research

Though an objective examination has shown forthcoming development as likely to be both difficult and lengthy, there is *one* branch of German aviation activities which seems to justify greater optimism and to promise results in an early future, namely aeronautical research.

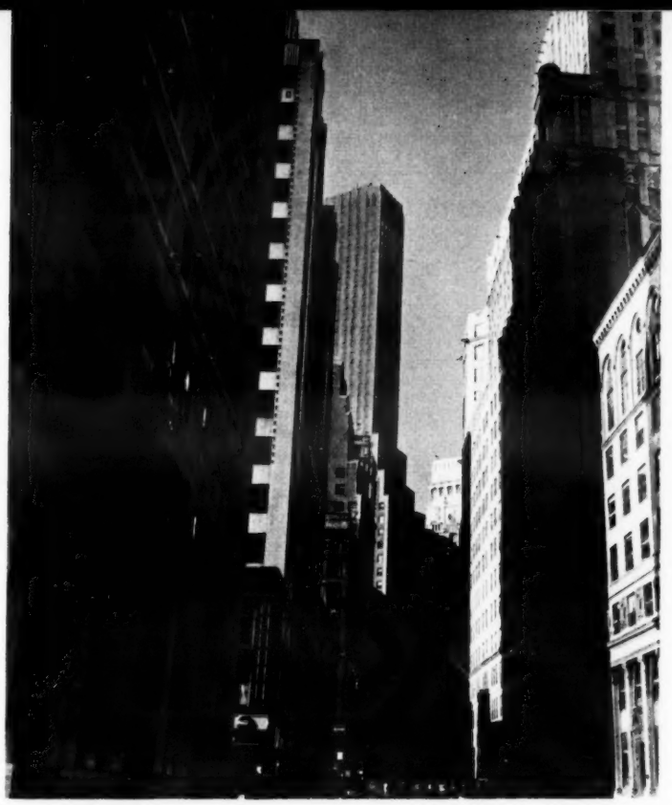
A substantial number of West German universities have created chairs and research institutes, which work in close collaboration with the larger research institutions that have been reactivated or newly established in various parts of Germany with funds from the Land governments. Special mention should be made of the Deutsche Versuchsanstalt für Luftfahrt (D.V.L.) in Essen-Mühlheim, with branches in Aachen, Bonn and elsewhere; the Deutsche Forschungsanstalt für Luftfahrt (D.F.L.) in Brunswick, with institutes for every possible branch of aeronautical engineering; the Ausschuss für Funkortung (Radio Navigation Committee) in Düsseldorf which —like many other institutes—was founded on the initiative of Under-Secretary of State Professor Brandt.

German engineers have not lost touch with international research. Several aeronautical congresses were held in Germany in 1954, and a good number of Germans took part in similar meetings elsewhere. The files of these research centres may well contain valuable material and an intellectual working capital capable under certain conditions of accelerating development in the industry to a surprising extent.

EEH

The Trend towards Diversification of Production

AVIATION STOCKS ON THE NEW YORK STOCK MARKET



As you were...

As if all the parts had been rehearsed, the curtain raiser to a January advance in aviation stocks witnessed a year ago was repeated at the beginning of 1955. Admiral De Witt C. Ramsey, President of the Aircraft Industries Association of America, recorded gratifying results in his final report for 1954, but also mentioned a slight drop in the output of military aircraft which, he thought, would continue during the next two years. Stock market commentaries also warned that the tendency towards reduction in Government arms expenditure should be borne in mind when assessing all aviation stocks... Whereupon President Eisenhower came on the stage and—exactly as last year—asked for Air Force appropriations in his Budget Message which banished all thought of reserve towards aircraft industry shares and set stock prices skyrocketing and ticker machines burning up the tape.

A few examples of price gains within a single week suffice to illustrate the process:

	New York prices	
Stocks	*Jan. 18th, 1955*	*Jan. 25th, 1955*
Boeing	71 ½	79 ⅞
Chance Vought	32	35 ½
Douglas	125 ½	137 ⅝
Lockheed	51 ½	58 ¾
North American	53 ⅜	56
Republic	38 ¾	41 ½

In other words, the stock market is remaining true to the aircraft industry. And the results for last year and prospects for the current year would seem to support its confidence.

Overall picture of the U.S. aircraft industry

According to the A.I.A. figures, the American aircraft industry delivered aircraft, engines, propellers and parts to a total value of $8,600,000,000 during 1954, a figure remarkably close to the previous year's total of $8,500,000,000. Sales by the twelve leading firms, approx. $5,300,000,000, were the highest since the war. Although the total labour force employed fell from 830,100 in January 1954 to 797,400 in September, the aircraft industry remained the United States' biggest single employer, with a total payroll of $3,500,000,000.

Though Admiral Ramsey forecasts a slight reduction in the number of service aircraft that will be delivered in 1955, he also states that this falling off will not have very much effect on the labour force, operating revenue or airframe weight, for the following reasons: aircraft now in production are considerably bigger; a marked increase in the output of guided missiles is to be expected; research and development contracts stand at a remarkably high level.

Admiral Ramsey predicts an output of between 9,700 and 10,000 service aircraft in 1955, a figure which is not seriously behind the record results for 1953 and 1954 (11,500 and 10,500 respectively).

The American lead in the civil transport aircraft market was still unbroken: 321 such aircraft were delivered during 1954, including 130 twin-engined executive aircraft and 91 commercial transports for 36 passengers or more. Orders were in hand for 1955 for a total of 175 large airliners.

Finally the A.I.A. President estimates that total probable sales of the aircraft industry during 1955 will be in the region of $7,900,000,000 to $8,100,000,000.

Position of the individual manufacturer

In the list of aviation shares quoted on the stock market, 1954 brought the addition of Chance Vought Aircraft; on the other hand, the stock of Consolidated Vultee Aircraft Corp. (Convair) disappeared from the market. Here it should be pointed out that these changes are at present significant only on the stock exchange: the position of the two firms as competitors in the aircraft manufacturing field remains substantially the same.

Chance Vought, until 1953 one of the four operating divisions of United Aircraft Corporation, separated from this group early in 1954 to continue as an independent company. Divisions remaining in the United Aircraft Group are Pratt & Whitney Aircraft Division (engines), the Sikorsky Aircraft Division (helicopters) and the Hamilton Standard Division (propellers and accessories). Rumours circulating in stock exchange circles at the beginning of 1955 that the withdrawal of Sikorsky was also under consideration have not so far received any official confirmation and should therefore be regarded with discretion.

Principal U.S. aviation stocks, with capital, dividends, stock prices, etc. (a)

Aircraft firms with Fitch rating (b)	Par value and number of shares		Dividends 1953 %	Dividends 1954 %	Price 25th Jan. 1955	High 1954	Low 1954	Profit per share (d) 1953 in $	Profit per share (d) 1954 in $	Short term liabilities million $	Realizable assets million $	Liquid assets million $
Aircraft Industry												
Beech Aircraft CCC	($ 1)	599,865	0.75	1.25	.	26	9⅞	3.87L.	5.64	19.4	23.8	5.15
Bell Aircraft B	($ 1)	1,290,230	1 00	1.25	26	25	11⅝	1.96	.	31.6	51.3	6.10
Boeing Airplane B	($ 5)	3,246,436	1.75	2.00	79⅞	75	23¼	6.26	11.75 (e)	149	209	20.7
Chance Vought Aircraft X	($ 1)	1,079,619	—	0.80	35½	38⅜	22	.	6.75 (e)	15.6	29.1	10.6
Curtiss-Wright CCC	($ 1)	6,985,387	0.60	1.00	18¾	18⅝	7¾	1.36	2.00 (e)	65.8	157	27.8
Douglas Aircraft BB	(no par)	2,459,860	3.25	6.50	137⅝	130¼	39½	7.73	14.70	113	184	51.5
Fairchild Engine & Airplane CC	($ 1)	2,887,758	0.80	0.80	17½	18¼	9⅝	1.74	1.50 (e)	45.1	60.6	32.4
General Dynamics B	($ 3)	2,182,000	2.25	3.25	91⅝	82¼	36	7.01	8.00 (e)	115	171	38.9
Grumman Aircraft Engineering B	($ 1)	2,000,000	2.00	2.00	40	39⅝	22⅜	3.56	5.35 (e)	47.7	75.4	18.3
Lockheed Aircraft B	($ 1)	2,684,753	1.62½	2.85	58¾	51⅝	26	5.79	8.50 (e)	182	221	44.0
Glenn L. Martin CC	($ 1)	2,270,967	—	0.91	38⅝	32½	15⅛	6.42	9.50 (e)	39.4	54.7	13.2
McDonnell Aircraft Corp. B	($ 5)	720,000	1.00	1.00	.	32	19	6.17	5.03	29.8	39.2	1.71
North American Aviation CCC	($ 1)	3,435,033	0.75	2.75	56	52¼	20	3.72	6.46	157	217	38.5
Northrop Aircraft CCC	($ 1)	1,479,210	0.46	1.04	36¾	34½	7½	2.38	2.63	37.8	47.9	14.5
Republic Aviation CCC	($ 1)	1,216,540	1.24	1.82	41½	43⅞	20	6.21	8.00 (e)	79.7	99.3	7.32
Ryan Aeronautical CC	($ 1)	381,000	0.50	0.50	.	31½	14⅞	3.80	.	12.1	18.7	8.70
Solar Aircraft CCC	($ 1)	672,783	1.05	1.05	24⅜	25¾	14¼	4.24	3.04	16.4	25.2	2.81
United Aircraft Corp. B	($ 5)	3,238,857	2.75	3.50	83½	79¼	45¼	6.23	7.65 (e)	114	186	51.3
Airlines												
American Airlines CCC	($ 1)	6,496,245	0.50	0.60	21⅞	22⅝	11½	1.86	1.50 (e)	51.0	85.2	54.5
Braniff Airways CC	($ 2.50)	1,279,170	—	0.50	15	17	6⅛	0.01	2.90 (e)	8.98	16.0	6.48
Capital Airlines CC	($ 1)	787,978	—	5% stk.	24¼	27⅛	8⅝	2.10	2.00 (e)	6.19	10.9	6.29
Eastern Air Lines CCC	($ 1)	2,478,601	0.50	0.50	37	40	21⅝	3.20	3.00 (e)	45.3	59.6	38.5
Flying Tiger Line X	($ 1)	784,452	—	—	.	7⅝	4⅛	2.30	0.60(L.)	2.95	4.65	0.51
National Airlines CC	($ 1)	1,016,302	0.55	0.60	23⅛	27	12½	3.99	4.42	9.23	8.23	3.74
Northwest Airlines C	($ 10)	820,933	—	—	19⅛	19¾	7½	1.84	1.90 (e)	13.0	18.4	9.66
Pan American World Airways CC	($ 1)	6,096,722	0.65	0.80	18	20⅜	9⅜	1.77	2.50 (e)	61.1	75.5	32.6
Seaboard & Western CC	($ 1)	.	—	0.30	.	9	5½	0.59	.	3.01	3.38	1.19
Trans World Airlines CC	($ 5)	.	10% stk.	.	26¼	30⅝	13⅛	1.52	2.50 (e)	43.0	43.7	25.5
United Air Lines B	($ 10)	2,463,068	1.50	1.50	36⅞	38⅜	21⅛	3.28	3.75 (e)	45.8	52.0	28.8

Notes:

(a) Figures in this table are taken from Dominick and Dominick's "Stock Guide" (New York), "Standard Listed Stock Reports" of Standard and Poor's Corp. (New York), "Fitch Stock Ratings" of Tucker, Anthony & Co. (New York).—Only common stock is listed, not preference shares.—*No guarantee of accuracy by Interavia.*

(b) Fitch Stock Ratings divide shares into four categories, A to D, the best stocks in each branch of industry being graded AAA, the weakest D.—X = no Fitch rating quoted.

(c) As already distributed.

(d) Dollar values of dividends and net profits per share have been adjusted to allow for changes in capital (stock splits etc.); for example, Douglas announced a profit of $15.46 per share on 1,202,552 shares for 1952—53. In May 1954 there was a 2 : 1 stock split, so that profit per share for 1953—54 was $14.70 on 2,459,860 shares.—The doubling in profit is expressed as follows after adjustment: profit for 1953: $7.73; profit for 1954: $14.70.

(e) Estimated.

(L) Loss.

However that may be, the separation of Chance Vought has proved beneficial to both parent and subsidiary companies. United Aircraft announces a net profit of $18,804,884 ($5.52 per share) for the period January to September 1954, compared with $15,873,870 ($4.68 per share) for the corresponding period of 1953. Profit per share for the full year is estimated at $7.65 ($6.23). United's order backlog rose from $1,075,000,000 on March 31st, 1954 to $1,125,000,000 on June 30th and $1,225,000,000 on September 30th, a remarkable result when most leading firms report a decline in their backlogs.

The independent Chance Vought company made a profit of $4.77 per share between January and September 1954, reflecting total sales of $111,671,502. Total profit for 1954 is estimated at $6.75 per share. Order backlog, given as $248,000,000 on September 30th, rose by $45,000,000 in October through a Navy contract for carrier-based jet fighters.

The measures taken by United Aircraft are of fundamental importance since they form a typical example of the whole aircraft industry's efforts to advance from one-sided dependence on Government orders for service aircraft to a greater versatility in its production programmes. Relieved of organizational responsibility for Chance Vought, United has for example been able to set the accessories production of its Hamilton Standard Division on a broader basis, which will have a beneficial effect on the group's ability to meet crises. This central problem in the aircraft industry will be dealt with in greater detail in the next section.

Admittedly the opposite process—the taking over of Convair by General Dynamics on May 1st, 1954—also does not appear to bring bad results in the present state of the market. Known up to the end of World War II only as submarine builders (Electric Boat Co.), General Dynamics had already acquired the Canadian aircraft firm of Canadair Ltd. in 1947 and, now that it has also absorbed Convair, holds major aviation interests. The group's net profit per share has developed as follows during recent years: 1951 $4.69; 1952 $5.72; 1953 $7.01; first half 1954 $4.24.

Nor do the other members of the American aircraft industry have cause for dissatisfaction. For example, Douglas Aircraft's recently published preliminary report for the 1953—54 business year (up to November 30th, 1954) announces a net profit of $14.70 for each of 2,459,860 shares outstanding. The corresponding figures for 1952—53 are $15.46 on only 1,202,552 shares outstanding. In other words, Douglas's profit has practically doubled. No wonder that the firm, having announced a two-to-one stock split in May 1954, should be

planning a further three-to-two split for the end of February 1955. In addition, a special dividend of $0.75 is being paid, as well as the normal quarterly dividend of $0.75.—North American too is paying a quarterly dividend of $0.75, Boeing $0.50 plus a bonus of $0.62½ on December 10th. Further details will be found in the accompanying table.

The omnivorous accessories industry

Despite the generally very satisfying results obtained in 1954, stock market handbooks continue to advise a certain amount of caution where aviation stocks are concerned, using the following stereotyped arguments:

— Changes that might be made at any time in the military procurement programme represent an unmistakable risk for the whole industry.

— All aircraft manufacturers would have to make substantial investments as soon as they begin to develop commercial jet transports.

Though the second argument applies at present to only a relatively small number of manufacturers, the first objection touches a raw spot in the aircraft industry, which, however, is now beginning to heal. At any rate, these doubts, fully shared a year ago, cannot now be entirely supported, as most of the leading manufacturers are making visible efforts to get away from excessive reliance on purely military aircraft production.

A big proportion of aircraft manufacturers are now participating in the development and production of guided missiles, including Bell, Bendix (*Loki, Thalos*), Boeing (F-99 *Bomarc* pilotless fighter), Chance Vought (*Regulus*), Convair (*Terrier*), Douglas (*Nike* and *Honest John*), Fairchild (*Petrel,* Wyandanch guided missiles division), Lockheed (guided missiles division recently greatly expanded), Glenn L. Martin (*Matador* and *Sidewinder*), Northrop, to name but a few.

Projects for atomic aircraft power plants (Convair Division of General Dynamics, General Electric, North American Aviation, Pratt & Whitney Division of United Aircraft Corp. etc.) may not yet be bringing in profits, but they do represent a promising bill on the future.

Above all, however, aircraft firms in increasing numbers are entering the accessories business, which not only holds out better earning prospects in both the civil and the military field, but also—perhaps an even more important point—offer better production alternatives.

Any attempt to paint a picture of the accessories industry would be beyond the scope of this article, even if it were limited to the barest details. However, in order to give some idea of what is meant, a table of representative figures is included for a single, though important, branch of the accessories industry, namely electronics. Yet even this limited view cannot be complete. The American electronics industry at present comprises some 200 major firms, whose number is growing every month. In the 1952—53 year alone the figure increased by 33%. Then a considerable number of leading firms (e. g., Hughes, Gilfillan etc.) are not quoted on the stock market. Finally, it is difficult to segregate the electronics industry completely from the aircraft industry, since—as already stated—the latter has now begun to participate in this rewarding branch of production.

Only a few random details can be given of the electronics firms covered by the table. The size of the leading manufacturers can be judged from their employment figures: General Electric 220,000, International Telephone & Telegraph 100,000, Radio Corporation of America 65,000 etc. Aeronautical items frequently take only a relatively modest place in the production programmes of these firms. For example, General Electric meets nearly 25% of the American demand for electrical utility equipment, while International Telephone & Telegraph and its subsidiaries supply telephone instruments and accessories to Britain, continental Europe and South America and operate telephone systems and submarine cables in a large part of Latin America.

One thing, however, is clear; most accessories firms show that "versatility of production" that has hitherto been missing in the pure aircraft industry. To name only one example: Bendix Aviation is by no means limited to electronic products, but also makes wheels, tyres and brakes for aircraft and cars (suppliers to General Motors, Ford, Chrysler etc.). The firm supplies shipping yards and railways, builds guided missiles and television sets. In short, Bendix Aviation has an extremely varied "menu". And Bendix Aviation is in turn only part—though a major one—of the Bendix organization whose household articles, washing machines, refrigerators etc. are sold throughout the world.

In other words, the accessories industry does not scorn any money-making activities. It is so to speak omnivorous. And the leading firms in the aircraft industry, to whom their earlier limitation to pure aircraft manufacture brought headaches at every trade recession, are gradually developing a taste in the same direction.

Selected U.S. Electronics Stocks, with capital, dividends, stock prices, etc. (a)

Electronic firms with Fitch Ratings	Par value	and number of shares	Dividends 1953 %	Dividends 1954 %	Price 25th Jan. 1955	High 1954	Low 1954	Profit per share (d) 1953 in $	Profit per share (d) 1954 in $	Short term liabilities million $	Realizable assets million $	Liquid assets million $
Admiral Corp. CCC	($ 1)	2,358,276	0.87½	1.00	27⅜	29⅛	18¼	3.48	3.25 (e)	37.2	82.5	19.0
Bendix Aviation BB	($ 5)	2,266,922	3.00	4.00	102¾	105½	60	8.20	10.50 (e)	.	.	.
Borg Warner BB	($ 5)	2,399,617	1.67	1.67	36⅝	39	24⅞	3.26	2.90	56.6	165.0	77.3
Collins Radio Co. CC	($ 5)	.	0.39	0.43	.	67	19	3.90	6.83	30.3	37.8	5.42
Garrett Corp. B	($ 2)	728,135	1.49	1.60	37⅜	41⅞	24½	4.46	3.91	35.3	44.8	4.87
General Electric Co. BB	($ 5)	86,537,781	1.33	1.47	48⅝	48½	29	1.92	2.25 (e)	632.0	100.3	435
Intern. Telephone & Telegraph	(no par)	7,176,677	1.00	1.00	25¼	26¾	13⅞	3.12	3.25 (e)	159	315	45.3
Philco BB	($ 3)	3,771,850	1.60	1.60	37¼	39⅝	28	4.86	1.75 (e)	76	130	18.8
Radio Corp. of America CCC	(no par)	14,031,016	1.00	1.20	38⅞	39¼	22½	2.27	2.75 (e)	121	341	109
Raytheon Mfg. CC	($ 5)	2,394,636	—	10% stk.	18⅝	20⅜	7¾	1.53	1.39	50.6	80.0	12.8
Sperry Corp. BB	($ 1)	4,292,840	1.50	1.75	44⅛	45⅞	21⅝	3.79	5.75 (e)	159	221	18.0
Sylvania Electric Prod. B	($ 7.50)	2,703,037	1.82	2.00	44⅜	48⅞	31⅞	3.10	3.25 (e)	53	140	18.2
Westinghouse Electric BB	($ 12.50)	16,241,064	2.00	2.50	78⅝	80¾	50⅛	4.53	5.40 (e)	200	830	220

Notes a—e: see table of aircraft industry

What's in the Air?*

AVIATION POLITICS

• Swedish-Icelandic air agreement cancelled

Sweden has cancelled her air transport agreement with Iceland because the Icelandic private airline Loftleidir H/F operates cut-rate services across the Atlantic with the authorization of the Icelandic Government.—Loftleidir has meanwhile announced that it will run five Atlantic services a week during the summer of 1955.

• Russian defence estimates for 1955-56

The budget estimates for 1955—56 submitted to the Supreme Soviet (a total of 562,900,000,000 roubles) includes defence funds of 112,100,000,000 roubles, an increase of 11,800,000,000 compared with 1954—55 figures. Defence estimates thus form 19.9 % of the total budget (1954—55: 17.8 %). —It should not be overlooked, however, that considerable sums for defence purposes are generally included in the Russian budget under other headings (industry, education etc.), and are not directly recorded as defence expenditure. The increase in defence estimates is in line with the new Russian industrial policy, which plans to strengthen the heavy industry in the coming year, at the expense of the consumer goods industry.

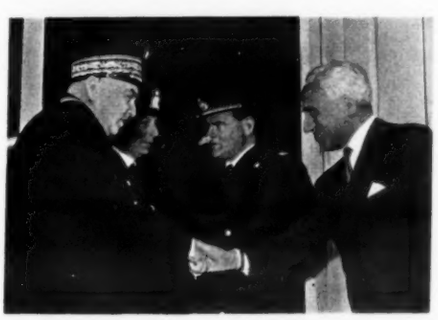
SERVICE AVIATION

• U.S. plans for Intercontinental Ballistic Missiles

In recent hearings before the House Armed Services Committee Air Force Secretary Harold E. Talbott and U.S. Air Force Chief of Staff General Nathan F. Twining have alluded to plans for the development of a guided missile capable of carrying a thermo-nuclear warhead over intercontinental ranges, and for the establishment of an intercontinental nuclear-propelled bomber force. The project, which is described as of "most critical importance to the U.S.A.", represents one of the measures which will enable the strength of the armed forces to be cut by 350,000 during the next 17 months.—In its semi-annual report published at the end of January, the U.S. Atomic Energy Commission also hints at new "major developments" in the field of nuclear weapons, but gives no details. Since the beginning of the World War II "Manhattan Project" a total of $ 13,200,000,000 has been spent on the atomic energy programme. Uranium mining in the United States has now reached a point where it is faster than the uranium can be processed.

• Sixth U.S. atomic battery goes to Europe

U.S. Army Headquarters in Washington have announced that a sixth battery of atomic cannon is shortly to be sent to Europe.



On a recent visit to Italy, *General Fay*, Chief of the French Air Staff, (left), inspected the Fiat works in Turin, where he was greeted by *Professor Vittorio Valletta*, Fiat President (right). Behind them, *Generals Raffaelli* and *Remondino*, Chief and Deputy Chief of the Italian Air Staff respectively.

Brigadier General Donald L. Hardy (left), Chief of the Air Force section of the Military Assistance Advisory Group, Japan, with Lieutenant General Kentaro Uemura (right), Chief of Staff of the Japan Air Self Defence Force, inspecting one of the T-33 trainers recently supplied by the United States to the Tachikawa training centre near Tokyo.

• Professor von Karman resigns U.S.A.F. consultant post

Professor Theodore von Karman has resigned from the post of Chairman of the U.S. Air Force Scientific Advisory Board, which he has held since 1944, to devote his full time to his activities as Chairman of N.A.T.O.'s Advisory Group for Aeronautical Research and Development. In recognition of his services to aeronautical science, the U.S. Air Force has offered him the honorary position of Chairman Emeritus of the Scientific Advisory Board. New Chairman of the S.A.B. is Dr. Mervin J. Kelly, Executive Vice-President of Bell Telephone Laboratories.

R. J. Pfeiffer has been appointed Director of Commercial Sales for Fairchild Engine & Airplane Corp., Hagerstown, Maryland. He was previously Domestic Sales Manager for the Convair Division of General Dynamics Corporation and played a leading part in the marketing of the Convair Liner.

• More Lockheed Neptunes for the French Navy

The French Fleet Air Arm, which already possesses 25 Lockheed P2V-5 *Neptune* patrol bombers and anti-submarine aircraft, is shortly to receive five more under the Military Aid Programme. Three *Neptune* squadrons are to be formed.

AIR TRANSPORTATION

• Airwork Ltd. full voting member of I.A.T.A.

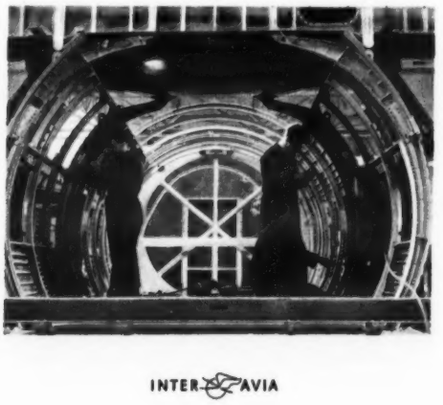
Airwork Ltd. was granted full voting rights in the International Air Transport Association on the introduction of its weekly all-cargo service between London and Frankfurt. This is the first time that any airline has received such rights on a freight service only.

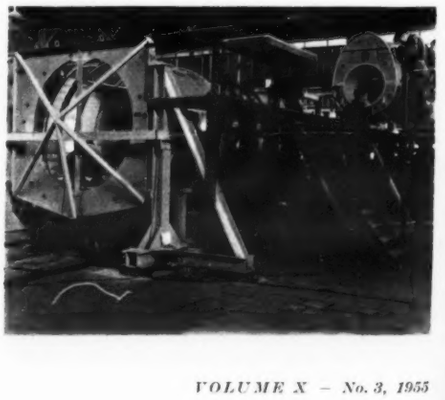
• $ 22,500 bonus for successful emergency landing

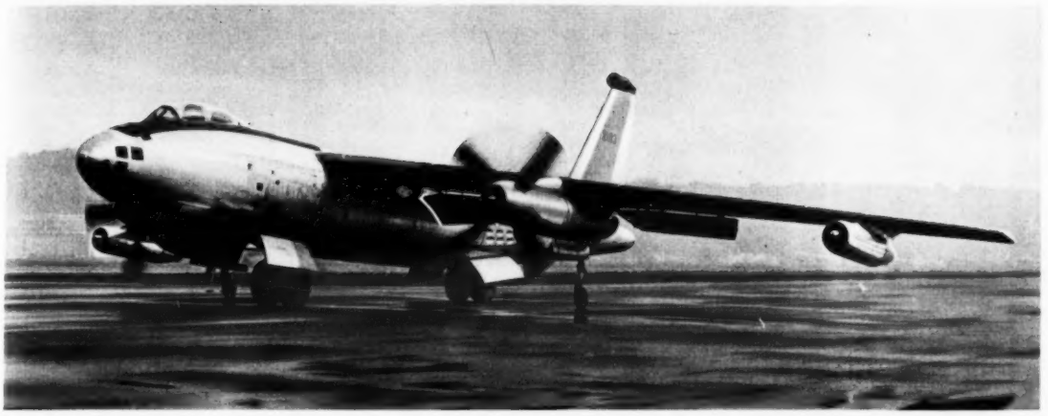
United Air Lines has paid a total bonus of $22,500 to the crew of a Convair Liner 340 which made an

* Extracts from *Interavia Air Letter*, daily international news digest, in English, French and German. All rights reserved.

Fokker F.27 Friendship: The Royal Netherlands Aircraft Factories Fokker are preparing quantity production of the *Friendship* twin-turboprop commercial transport. At present two prototypes are under construction; a third airframe is to be used for stress and fatigue tests in a water tank.







Boeing XB-47D: A Boeing *Stratojet* bomber converted into a flying test bed, for two Curtiss-Wright T-49 turboprops (approx. 10,000 e.h.p. each). The two normal outboard General Electric J-47 turbojets remain.

Great hopes were placed at the beginning of 1955 on General *Adolf Galland*, former Chief of the German Fighter Command, for the organization of the future German air force. However, it appears that Galland is returning to Argentina without accepting such a post.

emergency landing in a cornfield near Dexter, Iowa, on January 20th, without injury to any of the 36 passengers or crew. The pilot and co-pilot get $10,000 each, and the hostess $2,500.

● Swissair 1954 results

During 1954 Swissair's turnover, at 110,000,000 francs, exceeded the 100,000,000 mark for the first time. Increase over 1953 (86,600,000) was 35.5%. —Passenger volume rose by 28%. For the first time more than 500,000 passengers were carried on a network which now covers 31,000 miles (1954: 544,838 passengers, 1953: 425,309). Freight volume + 22%, mail + 19%.

● Backward-facing seats compulsory in Australia

The Australian Government has decided to make the fitting of backward-facing seats in commercial airliners compulsory. All new aircraft supplied from January 1st, 1957 must have such seating.

INDUSTRY

● First U.S. civil turboprop

The Allison Division of General Motors Corp. will probably concentrate on the domestic market for its 501-D.10 turboprop, the civil version of the military T-56, as present foreign demand is mainly for engines from other countries. Four American airlines are said to be interested in this engine.

● Northrop joins Garrett Board

John K. Northrop, founder and former President of Northrop Aircraft Inc., who retired from this position in November 1952 and has since been associated with The Garrett Corp. (parent company of the AiResearch Co.) in an advisory capacity, has been elected to the Board of Directors.

● Swift production to be stopped?

Rumours that production of the Vickers-Supermarine *Swift* jet fighter was to be stopped would seem to be confirmed. Well-informed circles in London state that further orders for the aircraft will be cancelled, and no further *Swift* fighter squadrons will be formed. An official announcement is expected.

● Training courses for French aircraft industry

The *Etablissements de Formation Professionnelle de l'Industrie Aéronautique* (Vocational Training Establishment for the Aircraft Industry) announces the following training courses: aeronautical engineering, in Toulouse and Ville d'Avray, and apprentice courses for the aviation industry, at Bourges, Châteauroux and Levallois-Perret.—Enquiries and registrations before May 1st, 1955; address: 6, rue Cimarosa, Paris 16.

● Decca Navigator Italiana

The capital of the Decca Navigator Italiana SpA recently founded in Rome (10,000,000 lire) has been subscribed in equal amounts by Decca Navigator Co. Ltd., London, Société Française Radio-Electrique, Paris and an Italian finance group led by Assicurazioni Milano.—The new company, which is responsible for production and installation of Decca equipment in Italy, has also been entrusted with the Greek and Turkish markets. President: Engineer Renato Manetti; Managing Director: Lieutenant Colonel Dr. Publio Magini.

FLYING EQUIPMENT

● The prototype of the Spanish *Hispano Aviacion HA-200 R-1* twin-jet trainer is shortly to begin flight testing. It is a two-seat all-metal low-wing monoplane with two Turboméca *Marboré II* turbojets of 880 lbs. take-off static thrust each.—Span 34 ft. 2 ins.; wing area 187.3 sq.ft.; gross weight 7,081 lbs.—Max. speed 440 m.p.h. at 29,500 ft.; rate of climb near the ground 2,680 ft./min; service ceiling 40,000 ft.; range 1,060 miles.

Air Force General *Mario Pezzi* (left) has been appointed Secretary General to the Italian Defence Ministry. General Pezzi held the world altitude record in 1938. He has been replaced in his previous post as head of the Defence Minister's personal office by General *Silvio Napoli* (right), formerly Inspector General for Flight Safety and Telecommunications.

● Japan has also been working of late on a number of projects for jet trainers. Main data for the *Kawasaki KAT-2* (two Turboméca *Marboré IIs*): span 36 ft. 1 in., gross weight 5,510 lbs., max. speed 435 m.p.h.

● The French *S.N.C.A. du Nord* is working on the development of a new four-seat aircraft for use by aero clubs and as sports and touring aircraft.

● Société Fouga has received an order for two prototypes of the *Fouga CM. 170-M Magister,* a naval version of the jet trainer. The naval version will have the usual features of carrier-based aircraft and be fitted with arrester hook, equipment for catapult take-off and a modified Messier undercarriage.

● The *IAME I. A. 38* four-engined cargo aircraft, designed by Dr. Reimar Horten, is under construction at the Instituto Aerotecnico of the Argentine Government aircraft works. It is a flying wing model.—It is also announced that production of the ten *IAME Pulqui II* jet fighters has been suspended.

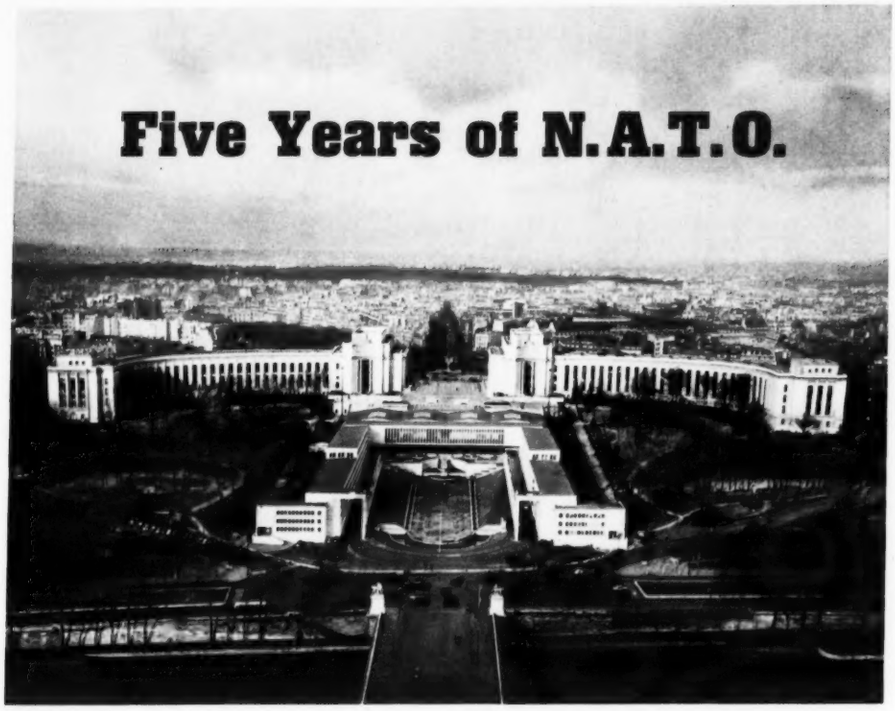
● Bristol is reported to be working on a development of the *Bristol 173* helicopter, using the Napier *Oryx* as power plant.

● By the time these lines appear in print, Lockheed Aircraft is expected to have announced *production plans for a turboprop commercial transport.* The new aircraft is said to be bigger than the L-1449 project, though it will use the same engines (Pratt & Whitney PT-2 of approx. 6,000 e.h.p. each). Lockheed does not plan to use the designation L-1449 for the new model.

● At the beginning of February the U.S. Navy began flight tests on a new patrol airship, the *Goodyear ZPG-2W.* It is fitted with special radar equipment for aircraft and submarine detection, but otherwise corresponds to the ZPG-2 airship which is in quantity production: two 800 h.p. Wright *Cyclone 7s*; crew of 21; length 342 ft.; volume 975,000 cu.ft.

● The *experimental vertical take-off aircraft* developed by Bell Aircraft has the following structural features: conventional airframe with simple strutted high-set wing, glider fuselage with open cockpit and single tail unit with T-shaped elevator unit. Span 26 ft., length 21 ft., gross weight 2,000 lbs. Two tubular steel skids, such as are used in helicopters, serve as landing gear. The two Fairchild J-44-R turbojets of approx. 1,000 lbs. static thrust each are fitted one on either side of the fuselage.—Unlike the Convair and Lockheed V.T.O. models, which are set up vertically on their tails for take-off and landing, the Bell type carries out these operations from normal position, with the two engines tilted 90° downwards from the horizontal, so that the exhaust gases strike the ground. For climb and horizontal flight the engines are then turned back parallel to the aircraft's longitudinal axis.—For control purposes, the Bell aircraft has not only normal elevators, rudder and ailerons, but also compressed air nozzles in the tail and at the wing tips for control during vertical flight.

Five Years of N.A.T.O.



N.A.T.O. headquarters in the Palais de Chaillot, Paris.

On January 30th, 1955 the Information Division of N.A.T.O. published a review of five years of N.A.T.O.'s work, by its Secretary General Lord Ismay. At about the same time the Royal Netherlands Military Association "Ons Leger" (Our Army) brought out an excellent booklet entitled "Five Years of N.A.T.O.," with contributions from leading Atlantic statesmen and military. In actual fact, the North Atlantic Treaty was signed in Washington on April 4th, 1949, so that in a few weeks time the Organization will be celebrating its sixth birthday . . .

Whether five or six years are counted, it does not appear as either arbitrary or fortuitous that there should be a special urge at this time to render an account of past progress. N.A.T.O. today is unquestionably on the threshold of a new phase in its existence.

If the Paris Agreements are ratified and West Germany is admitted into the North Atlantic Treaty Organization, the significance of the event will by no means be limited to the fact that the fourteen N.A.T.O. countries with their total population of 385 millions (Belgium, Canada, Denmark, France, Greece, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Turkey, the United Kingdom, the United States) will be joined by a fifteenth partner with 50 million population and a substantial industrial potential. The decisive point will rather be that it will mark the final settlement of World War II and change the face of the West.

Such a far-reaching transformation in the European climate would have been quite unthinkable if it had not been prepared step by step by the successful activity of N.A.T.O., an organization that, at the time of its creation, was itself something quite new and unaccustomed.

It is not necessary to go back in history more than a few decades to find a quite different type of alliance, which had been customary for centuries and had always been looked upon as the only possible type, namely pacts merely binding the signatories to provide each other with military support in the event of war. In peacetime the pacts were locked away in the foreign ministries' safes and had not the slightest effect on the life of the nations concerned. No wonder that such alliances were of a fleeting nature, that allies were not infrequently changed overnight—witness the confusion of secret treaties that was the order of the day at the time of the Entente Cordiale and the Triple Entente.

Only when these historic forerunners of N.A.T.O. are recalled can it be judged what it means that fourteen countries should maintain a common headquarters in Paris in peacetime, that units from all the N.A.T.O. powers should be combined into mixed Allied forces, that numerous common exercises should be held each year, that European pilots should receive their training at American and Canadian bases, that the United States should help to give the European aircraft industries a new lease of life—in brief, that N.A.T.O. should have succeeded in arousing more than a dozen sovereign states to effective collaboration in the political, military and economic fields.

Lord Hastings Lionel Ismay (United Kingdom), Vice-Chairman of the Atlantic Council and Secretary General of the North Atlantic Treaty Organization.

Left: *General Lauris Norstad* (United States), Air Deputy to the Supreme Allied Commander Europe. Centre: *General Alfred M. Gruenther* (United States), Supreme Allied Commander Europe (Saceur), with headquarters (SHAPE) in Paris. Right: *Air Chief Marshal Sir Basil Embry* (United Kingdom), Commander, Allied Air Forces Central Europe, with headquarters in Fontainebleau.

TOWARDS A NEW AIR ARMS POLICY

BY GENERAL ALDO URBANI, FORMER CHIEF OF STAFF OF THE ITALIAN AIR FORCE

General Aldo Urbani, who retired from the post of Chief of the Italian Air Staff on reaching the age limit last November, has been appointed chairman of two important Italian organizations, the *" Centro Studi per la Propulzione a Reazione "* (Centre for Jet Propulsion Studies) and the *" Centro di Informazioni e di Studio per lo Sviluppo degli Scambi Aeronautici con l'Estero "* (Information and Study Centre for the Development of Aeronautical Exchanges with Foreign Countries), both in Rome. — General Urbani has been in a position to follow closely the organization of air defence for the Western world; he has also taken part in most of the Allied conferences during the past five years; he is therefore very well qualified to sum up the advantages which the air forces of Western Europe have gained from American aid and to form a detailed opinion of the course that should be followed in order to ensure the health of the Western air forces.
Editors.

When the Atlantic Pact was formed, the United States, backed by Canada, took on an important task, that of aiding the European countries affiliated to N.A.T.O. in their efforts rapidly to close the breaches in their military organization. Such an undertaking was urgently needed in view of the imponderables in the political situation at the time. The task was particularly arduous, since the position as regards national armaments was basically critical in countries whose economies were not of the strongest and which had but recently emerged from a period of gigantic historical and social effort.

Drawing on their vast financial and industrial resources, the United States prepared and progressively applied a programme of military aid on a substantial scale based in particular on supplying the N.A.T.O. countries with arms and equipment already in production in the United States and in service with the American armed forces. Visits by groups of technicians, instructors and specialists, courses of familiarization or instruction organized in the United States and elsewhere, the progressive creation of inter-Allied Commands, the large number of manœuvres and exercises held at all command levels, have all helped to facilitate the uniform spread of new methods, the knowledge of military equipment and of the theories governing the use of modern means of warfare. This policy has been undeniably successful and was the best one for producing, within a relatively short time, positive results which have had a decisive effect on world politics during the past few years. However, the military apparatus of the Atlantic powers does not yet fully meet defence needs. If examination of the problem is extended to the special conditions existing in some of the N.A.T.O. countries, these considerations will be found to be accompanied by others of a distinctly less favourable nature, born of the limitations imposed by this process of assimilation and by the sudden introduction into more or less backward military organizations of arms, systems and means in use in a country so vast and so wealthy as the United States.

The following examination will be limited to the field of aviation, the only one of interest here.

Under the programme of immediate aid drawn up by the United States, the air forces of the various countries, having first gratefully accepted modern aircraft, along with complex and costly ground installations, have set to work to learn new methods and doctrines, train pilots and other specialized personnel, improve the professional quality of their cadres, build vast modern bases, solve complicated logistic problems which were rendered even more difficult by the distances from supply centres. To meet their new and constantly growing obligations countries have had to raise their military appropriations to the highest level compatible with their economic potential, and almost all European forces are today faced by serious difficulties.

If on the one hand the countries of Europe, and in particular those with a more modest economy, can pride themselves on having been able to create an air force (perhaps limited, but at any rate modern and efficient, and which it would have been madness to envisage without American aid), they are also preoccupied with a number of other problems. How can they maintain and enlarge these forces so as to ensure that they meet their defence needs? How is the present flying equipment, which becomes more out-dated and obsolescent every day, to be replaced? What would become of national air forces if the United States reduced their aid? How can they keep alive their own aircraft industries which, already reduced to minor proportions, are approaching a final crisis due to lack of work? If the aircraft industry disappeared, how could they meet the need for essential repairs and maintenance, and of production, even if the latter is reduced to trainer aircraft?

It is clear that the moment has come to re-examine the complicated problem of future aeronautical programmes with a sharper eye to reality, so as to arrive at rational compromises calculated to give smaller air forces more economical equipment, perhaps with reduced performance, but capable of being operated and maintained easily and safely.

On the basis of these principles, a number of light economical aircraft are already under construction or development. These are machines that will have smaller requirements as regards airfields and ground organization, cost considerably less to operate and can be produced in quantity, thanks to their low unit cost. The fact that the necessary bases can be smaller, and the consequent greater ease of decentralizing and transferring units form an additional factor of basic importance in view of the possible use of the new thermo-nuclear weapons.

In the true interests of Atlantic defence the United States should revise their system of military aid and, even if it entailed sacrifices for their own industry and economy, they should *reduce the volume of their deliveries of finished products and follow a replacement system based on the financing of production of aircraft and equipment in Europe on more economical lines, more nearly approaching the conditions of utilization peculiar to the European countries and to their economic potential.*

It would therefore appear to be time to embark seriously on European industrial collaboration as envisaged by Western European Union. Such collaboration is daily being recognized as increasingly essential, since all European countries are convinced that aeronautical problems are today so complex, so costly and of such vast proportions that they can only be solved on an international level.

The arms pool could offer a concrete means—though not easy of realization—of utilizing the productive capacity of the various European countries, through the integrated and standardized production of such aircraft and equipment as a careful examination shows to be most suited to operational conditions in Europe. *This integrated production programme should ideally be financed not only by the various countries who would be both producers and users, but with the effective aid of the United States.*

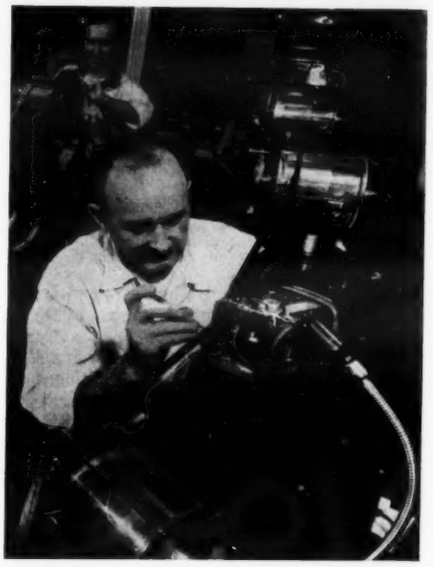
Europe's industries, including the most modest ones, could then look forward to a new lease of life and make the positive and concrete contribution to N.A.T.O. which they already would like to offer.

Such a new orientation in arms policy could mark a new era in the Atlantic alliance...

Aldo Urbani

The Bendix
Polar Path Compass System

The February issue of Interavia *(No. 2, 1955) contained an article on air navigation methods in the Arctic which cited remarks by two Scandinavian Airlines System navigation experts, K. Hagerup (Vice-President Operations) and E.S. Pedersen (Research Navigator). Both revealed that the Polar Path compass system developed by the Eclipse-Pioneer Division of Bendix Aviation Corporation is the main navigation instrument used by S.A.S. on its Arctic flights. The following is an extract from a description of the system received after the special Arctic issue had gone to press.*

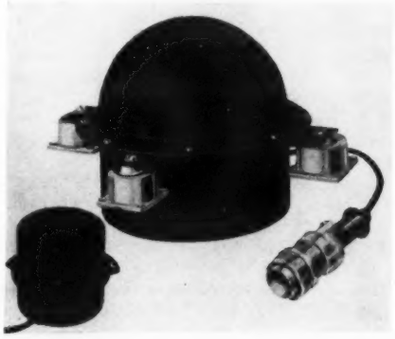


Extreme care is exercised in manufacture: all critical processes are carried out in completely dust-free, temperature and humidity-controlled rooms.

Flying in polar regions is faced by the difficulty that within a radius of about 1,000 nautical miles of the magnetic North Pole all magnetic compasses are useless. (In this region the horizontal component of the earth's magnetic field becomes almost zero, so that the compass is valueless as a reference system for horizontal direction indications.) — The job of indicating direction is here taken over by a directional gyro. In its older versions, however, the latter was not fully satisfactory as a navigation instrument over long routes. As the gimbal-mounted gyro axis, " tied " only in a horizontal level, in principle retains its position in space, while the earth rotates about its axis, the meridians constantly change their direction in relation to the gyro axis, i.e., the directional gyro is subject to " apparent " drift. Added to this " apparent drift ", the value of which depends on geographical latitude, there is the precession caused by mechanical defects, such as bearing friction, unbalance, etc. (random drift). If this precession is slight and constant, any flight in the northern hemisphere with the same directional gyro reading (in still air) would become an arc-shaped trajectory curving to the right by 15° times the sine of the latitude per hour. To correct this drift, the directional gyro indicator must be reset the appropriate number of degrees to the left at regular intervals, e.g., every 30 minutes, and the " grid heading " shown by the gyro checked by the astro compass. With this procedure the track becomes a succession of small arcs to the right and only slightly longer than the Great Circle track. The mean track, however, corresponds to the desired Great Circle or grid heading.

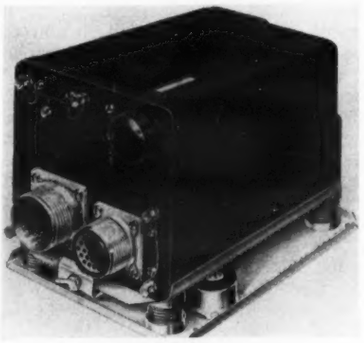
When S.A.S. made the first trans-Atlantic reconnaissance flights in preparation for their new Polar route between Europe and the United States, they tested a special directional gyro made by Bendix Aviation Corporation, with a random drift of only 1° per hour. It can also be connected to the autopilot. This " Polar Path " gyro can be used for flights on both Great Circle and rhumb line courses (a rhumb line is one which cuts all meridians at the same angle). By combining a precision gyro with a magnetic Flux Gate compass, the equipment will also give true headings at medium geographical latitudes. Here the gyro serves to stabilize the readings while the measuring element of the Flux Gate provides continuous magnetic data for resetting the gyro. Simplicity, low weight, compactness and ease of maintenance enable the equipment to be installed in all types of aircraft, from fighter to multi-engined transport.

Console controller for the Polar Path Gyro.



Pendulous Flux Gate transmitter (left) and directional gyro transmitter.

Compass coupler, to coordinate the electrical signals from the Flux Gate transmitter directional gyro and the console controller.



The complete Polar Path equipment consists of four components, which together weigh roughly 17.5 lbs. : pendulous Flux Gate transmitter, directional gyro transmitter, console controller and compass coupler. Thanks to its small diameter (2 7/8 ins.), the Flux Gate can be installed in the tail or the outer wings, where the magnetic influence of steel aircraft parts is lowest. The directional gyro transmitter and the compass coupler can be mounted anywhere in the aircraft. The console controller, fitted in the pilot's (or navigator's) instrument panel, takes up a space of only 2 × 2 5/8 × 5 3/4 ins. Signals can be fed to standard panel-mounted instruments of the R.M.I. type. — If the aircraft is already equipped with a conventional gyro-stabilized Flux Gate compass system, this can be used instead of the pendulous Flux Gate transmitter. For aircraft operating chiefly in Polar regions, the Polar Path can also be supplied without pendulous Flux Gate.

The *pendulous Flux Gate transmitter* weighs only 0.8 lbs. A magnet assembly and a miniature Flux Gate element are pendulously

suspended from one point of a float in an oil-filled case. The magnet assembly is free in azimuth, while the Flux Gate element is fixed in azimuth with respect to the case.

The *directional gyro transmitter* consists of an electrically-driven precision directional gyro with transmitting Autosyn. The mechanism is enclosed in a helium-filled case. On starting up, the gyro is erected automatically by acceleration torque, after which a torquer, controlled by a pendulum and electrical circuit, maintains the gyro axis in a horizontal position. — By the use of materials with a low coefficient of expansion, the centre of gravity is retained from —55 to +70° C, so that no temperature regulation is needed. This and other structural peculiarities, together with extreme care in manufacture (all critical processes are carried out in completely dust-free, temperature and humidity controlled rooms) enable random drift to be kept practically constant and to be reduced below the required maximum of 3° per hour. Tests in flight have shown random drifts of less than 1° per hour.

The *compass coupler* is the " control equipment " in which the electrical signals from the Flux Gate transmitter and the console controller are coordinated and transformed into suitable values for the course indicator and autopilot. Control elements provide for correction of the magnetic deviation and for checking the output impulses from the directional gyro and Flux Gate.

The panel of the *console controller* contains a function selector switch (top right), a drift correction knob and dial (top left), course setting knob, synchronizing knob and synchronizing indicator.

*

The function selector switch on the console controller sets the equipment to the directional gyro alone (1), the directional gyro combined with the Flux Gate transmitter (2), or the Flux Gate alone (3).

(1) Directional gyro alone is used not only in the vicinity of the Pole, where the earth's magnetic data are unreliable, but also for all flights on Great Circle tracks, i.e., by grid course. Compensation for apparent drift and the almost constant random drift is done automatically by the compass coupler. Magnitude and direction of the necessary correction are set by the drift correction knob and dial assembly. For flight on a rhumb line an additional correction, depending on latitude, direction and speed, is required ; this is taken from a table supplied with the equipment and set in by the same drift correction knob. — When the axis of the directional gyro has stabilized horizontally at any azimuth, the gyro is connected to the R.M.I. panel instrument. This is done by means of the course setting knob on the console controller, which sets the direction indication to the desired basic value (zero, grid heading or true heading).

(2) The combined use of directional gyro and Flux Gate (slaved directional gyro mode of operation) provides greater stability and accuracy on rhumb line courses than the separate use of the two elements. Gyro and Flux Gate are automatically synchronized when the synchronizing knob is pressed and maintained in this condition until the gyro is turned off.

(3) Flux Gate mode is provided as a stand-by operation. It is particularly useful in military aircraft where components may be damaged by enemy action.

*

The Polar Path system is fitted in all S.A.S. aircraft operating the new Arctic route and works to the full satisfaction of the crews. On these flights two navigators always work together. One works on maps and charts and calculates speed, wind conditions, position and desired grid course. The second navigator checks the Bendix directional gyro every 30 minutes with the aid of the astro compass and records the gyro's drift.

Two-Dimensional Retractable Ramjets

BY DIPL. ING. OTTO REDER, MADRID

Otto Reder was born on December 21st, 1900, and studied technical physics and aerodynamics at the Technische Hochschule, Hanover. Started 1925 at the Heinkel works, Warnemünde with development work on steel and electron wings. His special interests took him in 1932 to London as collaborator of Juan de la Cierva in the development of the direct control and vertical take-off autogiro. In 1938 he became head of the flight test department of Flettner helicopters in Berlin. From 1943 to the end of the war he directed the flight testing of the Ruhrstahl A.-G. X 4 guided rocket at Bielefeld and Peenemünde. Since 1950 he has been head of the helicopter and ramjet department of Aeronáutica Industrial S.A. in Madrid.

If ramjet engines are to be operated over a wider speed range, certain parameters, such as the area of the diffusor entry and the exhaust exit and the position of the diffusor lip in relation to the bow waves, must be made variable. Such geometrical variability is very difficult to design for in three-dimensional circular ramjets, but conditions become a great deal simpler in a flat " two-dimensional " engine.

As the author pointed out in 1951 [1], geometrical variability can be carried so far that the engine has the same profile as the wing, disappearing into the wing and forming an integral part of the latter when not in use *(fig. 1)*. The engine consists of a box-shaped section of the wing, between two tightly closed end plates. The leading edge is a tubular supporting spar. The covers forming the rear of the airfoil can be splayed out by means of a system of levers. This forms a " two-dimensional " duct inside.

Retraction of the ramjet considerably reduces drag during the acceleration period, when some other kind of power plant is needed to produce sufficient ram pressure for the ramjet to function. It is also of

[1] Spanish patent 199029 of July 31st, 1951 ; U.S.A. Patent Application Serial No. 276989, filing date March 17th, 1952 ; British Patent Application No. 16848 convention date July 31st, 1951.

advantage when the ramjet is to be used only for short-period power boosts.

In a helicopter or gyrodyne with blade-tip ramjets, retraction markedly improves performance in autorotation flight, when e.g., the power plant fails. It also opens up the possibility of using the ramjet merely as an auxiliary source of power for take-off and landing. It would be possible, for example, to build very simple vertical take-off combination gyroplanes without rotor gearing, which would have good high-speed performance and be economical to operate and maintain.

A difficult problem when normal fuels are used is that of starting the ramjet in flight. In the type of engine now proposed ignition can take place with the duct only partially open, i.e., reduced air intake. The duct can then be opened and the air-fuel ratio gradually increased, thus avoiding blow-outs.

An engine of this kind for the subsonic range (M=0.6 to 0.8) can be developed on a rotating test rig. This system has the advantage of enabling a practical helicopter rotor to be obtained at the same time. It is also possible that supersonic rotors can be developed later.

Work on two-dimensional ramjets was begun at Aeronáutica Industrial S.A., Madrid, in 1951 as a private venture. *Fig. 2* shows the simple rotor test rig used. Experiments began with a series of engines with different duct openings *(fig. 3)*. To begin with, no attempt was made at continuous variability, as problems of fuel injection, ignition and flame stabilization had first to be solved. Fuel used was ordinary automobile gasoline. The experiments have not yet been completed but they have already proved that a useful helicopter power plant can be developed along these lines.

A two-dimensional variable ramjet also offers advantages in supersonic aircraft. The increasing size of power plants has led to a tendency to combine their functions with those of the wing unit. Power plant and wing unit can form a single whole, as suggested in *fig. 4*.

[2] Cf. *Interavia*, No. 1, 1955, pp. 29-38

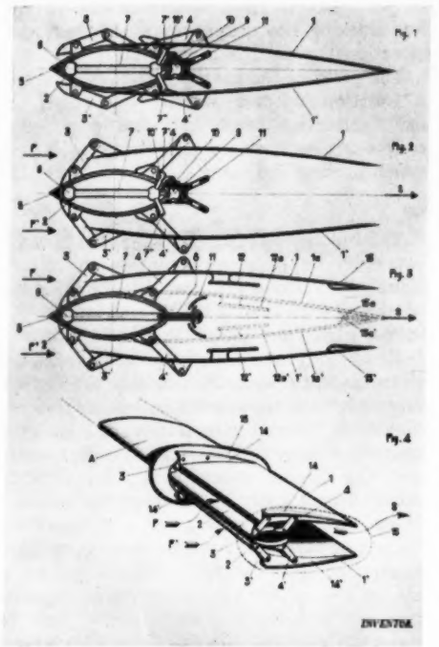


Fig. 1 : Geometrically variable and retractable ramjet according to O. Reder patent of July 31st, 1951.

Annular-wing aircraft (coleopters) [2] can also use two-dimensional variable ramjets with advantage. The engines could be built into the radial struts connecting the annular wing to the fuselage, and would constitute a power plant of greater thermal economy, with higher working temperatures and smaller air flow than can be obtained by the annular ramjets with very high air mass flow hitherto proposed. With such an arrangement it would be easier to provide for thermal insulation of the annular wing from the hot exhaust gases, so that the actual wing could be made of light metals (with no heat-resistance), protected locally where needed.

Fig. 2 : Rotating test rig for ramjets, at Aeronáutica Industrial S.A., Madrid.

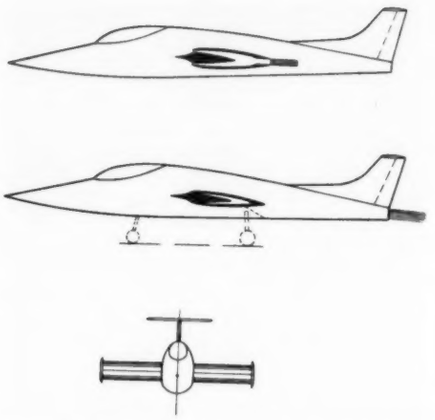
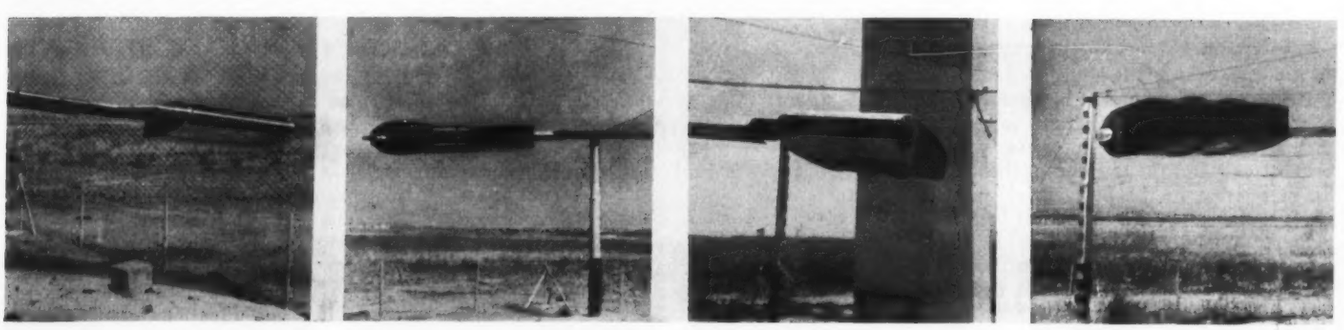


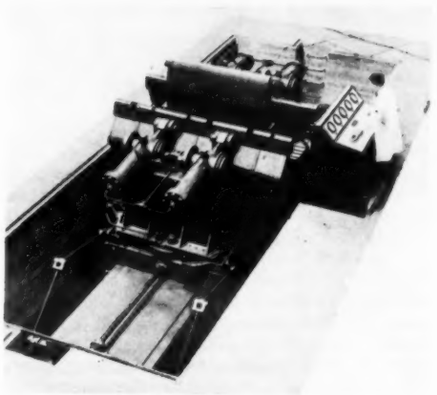
Fig. 4 : Aircraft with ramjet engine-wing (section through the wing, tips not shown) : **top** in high-speed flight, with power plant open ; **centre** with power plant closed and take-off rocket ignited ; **bottom,** front view with power plant open. Flaps can be provided for take-off and landing ; the control mechanism is in the fuselage and the wing tips.

*

A method of obtaining geometric variation and retractability in a ramjet has been indicated. In supersonic aircraft this leads to an "all-engine-wing", i.e., to a wing combining the functions of power plant and lifting surface. The retractable engine can also be used with advantage in rotor blade tips for gyroplane flight as well as in cases where the ramjet is required only for take-off and landing.

Fig. 3 : Experimental two-dimensional ramjets with various openings on a rotor blade tip.





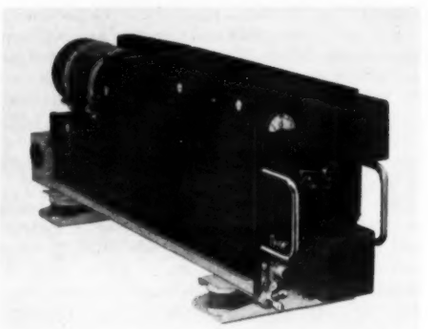
Equipment Round-Up

* **This 250-ton stretch press** was built by Ateliers et Chantiers de la Loire, Paris, in conjunction with S.N.C.A.S.O., who prepared the initial projects. The press has been in use for the past two years at S.N.C.A.S.O.'s Bouguenais branch plant.

* R/T equipment for 800 channels

The LearCal Division of Lear Incorporated, Santa Monica, California, has developed the LTR-800 VHF transmitter-receiver, which weighs only 25 lbs. and permits of use of all available R/T channels. A total of 800 frequencies at intervals of 50 kc/s can be selected within the 108 to 147.96 mc/s range. The equipment is simple to operate and meets both C.A.A. and military requirements.

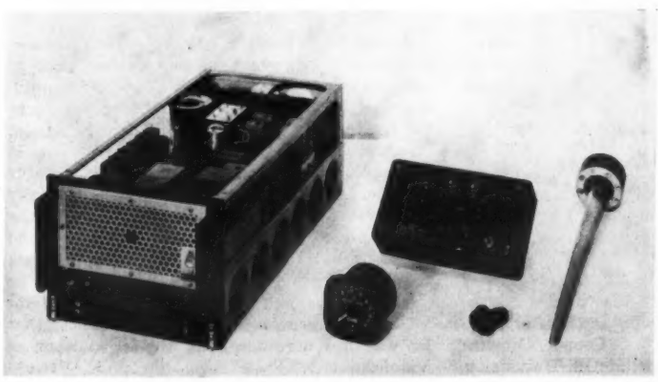
The complete installation consists of three main components : an 8-Watt transmitter, a robust quartz-stabilized receiver protected against interference from the aircraft's electrical equipment, and a small channel selector unit, fitted away from the rest of the installation in the cockpit instrument panel. The desired frequency is selected by means of two knobs and shown on a five-figure indicator on the channel selector. Normally, transmission and reception are on the same frequency, though for special purposes transmitter and receiver can work on different frequencies. When the equipment is set for reception, the transmitter modulator can be used as amplifier for the cockpit and cabin loudspeakers. This feature is of special value in cases of high noise level, as the output power of normal aircraft receivers then suffices only for headphone operation. Installation and maintenance are simplified by the use of a single connecting cable between the frequency selector and the transmitter-receiver.



* Australian Distance Measuring Equipment

A 200 mc/s DME system for distances up to 100 miles is produced by Amalgamated Wireless (Australasia) Ltd., of Sydney, under the designation VAN-3. The equipment has received a type certificate from the Australian Department of Civil Aviation, but is probably designed primarily for military use. — Picture shows the most important components of the *airbone equipment*, which weighs approx. 48 lbs. : left to right : Interrogator-responsor ; indicator (bottom, centre) ; control unit ; code lamp (bottom, right) ; aerial. The interrogator-responsor and the aerial can be installed at any point in the fuselage, while the other items are mounted on the pilot's instrument panel.

The operating principle of the VAN-3 is as follows : the airborne interrogator transmits 100 double pulses a second (pulse rate 100 c/s) on a frequency of 206 mc/s. These signals are received by the ground DME transponder and passed to the latter's transmitter, which returns them, exactly 12.4 microseconds after reception, in the form of a single pulse on a frequency of 224 mc/s. The double pulse consists of a " gating " pulse and a " triggering " pulse. This system is designed to prevent the transponder from being actuated by unwanted radiations. The ground station to be " called " is selected by means of a 12-stage selector switch on the airborne control unit. This switch varies the interval between successive pulses to the exact value to which the selected ground transponder will respond. For checking purposes the ground station also emits an identification signal at intervals of 20 seconds, which is shown as a morse signal by the code lamp in the cockpit. The same identification signal can also be relayed to the headphones.



As line-of-sight propagation is obtained at the frequencies used, maximum range depends on the aircraft's altitude ; in normal cruising flight it is approximately 100 miles. For greater accuracy in an airport zone, range can be restricted to 10 miles by means of a switch. The equipment can also be used for orbiting within a given radius of an airport DME transponder. For this purpose there is a small orbit indicator (at the bottom of the indicator unit) which marks deviations from the selected orbit radius by simple right or left deflections. A full deflection corresponds to a deviation of 0.3 miles from a 5-mile orbit. Nineteen different orbits (at intervals of 1 mile from 1 to 10, and of 10 miles from 20 to 100) can be selected by means of the switch on the right on the control unit.

The DME *ground station*, also made by Amalgamated Wireless (Australasia) Ltd., consists of two automatically operated beacons (transponders), one of which is a standby. Each transponder can reply simultaneously to up to 50 different aircraft.

Technical data of airborne equipment : — transmitter : peak R.F. output 400 Watts ; pulse length 2 microseconds. — *Receiver :* intermediate frequency 30 mc/s. — *Technical data of ground equipment : Receiver :* intermediate frequency 30 mc/s ; rejects pulses shorter than 1.5 microseconds. — *Transmitter :* peak R.F. output 4 Kw ; pulse length 5 microseconds ± 0.25 microseconds ; code pulse delay 20 microseconds. — Power consumption of whole equipment 2,600 Watts at a power factor of 0.86.

Book Reviews

Le Soudage Electrique par Résistance et son Application à la Construction Aéronautique. — By G. Moressée. Girardot & Cie., Paris, 1954 (French, 365 pages, price 7,800 francs).

In this luxuriously produced work the author has set out to collect together all available technical, theoretical, practical and economic knowledge on electric-resistance welding. He has created a kind of encyclopaedia on the subject, complete and concise, but without superfluous detail. The text is supplemented by 262 illustrations, 204 three-view drawings and 85 tables, all of very modern presentation. Technical data have been supplied by a large number of engineers and are illustrated by factory photographs showing the kind of work to which such welding can be applied.

The various categories of electric-resistance welding are clearly described : the principles and theory of spot welding, butt welding, seam welding, flash welding, etc. Each chapter, detailed and complete, discusses both electrical and crystallographic aspects and practical applications in aircraft manufacture, such as airframe construction, tanks, undercarriages, turbojets.

Since most large assemblies, including those having to bear considerable stresses, can now be welded, it is essential that welds be expertly done. The object of this book is to contribute to this result by describing the methods and machinery best suited for the purpose. It is thus an invaluable aid to the engineer, designer and workshop manager. It is completed by a glossary of special terms and an extensive bibliography. La.

Aerodynamik der Hub- und Tragschrauber Teil II : Berechnung des Rotors. — By Dr.-Ing. W. Just and Dr.-Ing. K. Jaeckel ; Report No. 3 in the series published by the German Helicopter Study Group, Stuttgart, 1954 (German, 190 pages, 80 illustrations).

Literaturverzeichnis des Hubschrauberwesens. By Dr.-Ing. W. Just, assisted by Dipl.-Ing. E. Jarosch ; Report No. 6 in the above-mentioned series, Stuttgart, 1954 (German).

Reports 1 and 2 in this extremely thorough series, which will be a valuable aid to all helicopter designers, were reviewed in *Interavia* No. 9, 1954. The present *Report No. 3* is devoted to the calculations concerned with the rotor and thus forms a continuation to No. 2 on general performance calculations for helicopters. The book opens with a description of hovering and vertical flight with reference to jet theory and the considerably more exact propeller theory. A mathematical account of the beating and swivelling motion of rotor blades is followed by methods of calculating the distribution of shear and tangential forces and rate of flow. Other sections examine the force and moment behaviour of the whole rotor and indicate calculations for the forces on the blade connections in extreme cases, such as pulling out or in gusts. Finally there is a bibliography with about 190 titles arranged according to the chapters of the book.

Report No. 6 provides a complete bibliography on the aspects of helicopter production covered in the first five reports in the series. Further titles are to be listed in later editions.

The attempt to classify all helicopter activities into 25 categories, including experimental work, flight testing, production problems and piloting systems, is of particular interest. As such a classification appears to be behind the Study Group's publications programme, further contributions to this series are to be expected. Re.

Träumer - Forscher - Konstrukteure — Das Abenteuer der Weltraumfahrt. — By Dipl. Ing. Heinz Gartmann. — Econ-Verlag GmbH. Düsseldorf, 1954. (German, 336 pages, DM 12.80).

"... Not all dreams come true, but the dream of generations of flying beyond the atmosphere to other planets will have a better fate."

With these confident words the author, well-known in the field of rocket engineering and astronautics, opens his new book on the history of space travel. The eventful stories of the dreamers, experimenters and designers are graphically described. Ganswindt, Ziolkowsky, Goddard, Oberth, Valier, Nebel, Engel, Eugen Sänger, von Braun... nobody who has made any decisive contribution to rocket research or space travel has been passed over. The author takes the reader behind the scenes, shows him rocket experimenters at work, lets him take part in test runs and shows that rocket engineering and space travel have long since passed the small-scale experimental stage. (Index to pictures and names ; bibliography). Ba.

Beiträge zum internationalen Luftrecht. Published on the occasion of Professor Alex Meyer's 75th birthday. — No. 32 in the series " Verkehrswissenschaftliche Veröffentlichungen " of North Rhine—Westphalia's Ministry of Economics and Transport. Editor : Under-Secretary of State Professor Brandt.

This collection of essays commemorating Professor Alex Meyer's 75th birthday, briefly mentioned in *Intervaia* No. 1, 1955, would probably have been little different if it had been edited by the famous jurist himself. It contains contributions in English, French, German, Italian and Swedish, by internationally known experts and members of the " second generation " . . . international law, transport law, insurance law . . . a true picture of the rich and varied work of Professor Meyer who has always valued the international nature of air law. (He was particularly gratified, for example, with the publication in 1948 of his monograph on " Le cabotage aérien ", his first book in French.) —The fact that Professor J. C. Cooper, Director of the Institute of Air Law, McGill University, Montreal, is among the writers in the present volume will doubtless also have pleased Professor Meyer, whose main work " Freiheit der Luft als Rechtsproblem " (1944), like Cooper's " The Right to Fly ", is one of the basic works on international air law.—Other contributors include Professor Abraham (University of Hamburg), Professor Ambrosini (University of Rome), Dr. J.-T. Lacour (University of Geneva), Professor de la Pradelle (Aix-en-Provence), Dr. H. H. Wimmer (of Allianz-Versicherung and executive head of the Deutsche Luftpool), etc. He.

Der Luftbeförderungsvertrag. — By Professor Dr. H.-J. Abraham. Verlag Ferdinand Enke, Stuttgart, 1955 (German, 80 pages, price DM 5).

The present treatise on the rights and duties of the air cargo carrier and the air cargo consignor under international and German law first appeared in summer 1954 in L. Goldschmidt's " Zeitschrift für das gesamte Handelsrecht und Konkursrecht ", of which the author (Professor of Law at the University of Hamburg) is co-editor. Its appearance now in separate book form, brought up to date to cover the latest court decisions, is particularly welcome at the present moment. The plans for Germany to re-enter the world of commercial aviation had revealed a need for a survey of such German regulations as are still in force, together with their critical assessment in the light of international legal developments. In addition, the old confusion between the provisions of the Warsaw Convention, national legislation and the general conditions of carriage accepted by the I.A.T.A. airlines is still far from having been cleared up. From this point of view the present monograph should be of interest to more than German readers. Abraham's book will be of value to all who have to deal either theoretically or in practice with the legal bases of air carriage. He.

Der Sprung von der Erde — By Richard Wunderer. Schönbrunn-Verlag, Vienna, 1954 (German ; 292 pages ; price 48 sch., DM 9.60).

A real boy's book, this story of the pioneers of human flight, which, while omitting none of the great names—Lilienthal, Pénaud, Chanute, Herring, Manly and so on—deliberately places the tragic figure of the Austrian pioneer Wilhelm Kress in the central position. Rightly so, as in his successes and disappointments the likeable designer of the first stable aircraft models really to fly, to whom it was not given to take the last step into powered flight, was a key figure in the struggle to conquer the air. That this book has now been published in Vienna may be regarded as a belated sign of recognition for Wilhelm Kress, whose greatest sorrow was that he was not considered as an Austrian or as Viennese... . He.

Das lustige Atom. — By Fritz M. Wolf. With drawings by L. Liesegang and numerous text illustrations. Vulkan-Verlag Dr. W. Classen, Essen, 1954 (German, 208 pages, price DM 9.60).

Humour, even when used to provide suitable relief in serious subjects, has never in itself been condemned by *Interavia*, as is evidenced by the review of " Humor in der Technik " also published by the Vulkan-Verlag. However, there are certain limits which humour should not transgress. To this reviewer it seems, to put it mildly, to be out of place to describe the atom bomb in " amusing " verse, though in justice to the author it must be admitted that only one chapter of this " poem " deals with atomic weapons and their effects. The major portion contains a popular description of the history of nuclear fission, written from beginning to end (including the list of contents) in rhyming verse. But this one chapter suffices to reduce the value of the whole. He.

Translations

Der Ueberfall am Chongchon. — By General S.L.A. Marshall. Translated from the English " The River and the Gauntlet ". Verlag Huber & Co. A.G., Frauenfeld, Switzerland, 1954 (German, 223 pages).

In view of the radical change in modern warfare and in particular the adoption of new psychological principles in the organization of combat units, the translation of this American book will be welcomed by German-speaking readers. General Marshall presents an objective, detailed examination of the impressions, experiences and reactions of the individual combat soldier in Korea. This is no sensational reporting, but an objective report aimed at improving tactical methods.

Soldaten im Feuer. By General S.L.A. Marshall. Translated from " Men against Fire ". Verlag Huber & Co. A.G., Frauenfeld, Switzerland, 1951 (German, 231 pages).

A forerunner to the above-mentioned Korea report by the same author, this book illustrates the foundations of the morale of a fighting unit by examples from World War II.

Flug durch zwei Welten. — By James Riddell. Translated from " Flight of Fancy ". Diana-Verlag, Zurich, 1953 (German, 271 pages).

The author of this attractive travel book flew a single-engined Percival *Proctor* to India, Burma, Siam, Malaya, Indonesia and Australia in 1948-49. Temple dances, jungle, rice paddies, bad weather flying. Richly illustrated. Gripping reading.

Books received

Publications scientifiques et techniques du Ministère de l'Air. Distributed by Service de documentation et d'information technique de l'Aéronautique, Paris :

No. 294. *Equilibres physico-chimiques et données thermodynamiques des mélanges gazeux aux températures élevées,* by G. Ribaud and N. Manson.

No. 295. *Recherches magnétochimiques sur l'anisotropie des polymères,* by Jean Ploquin.

No. B.S.T.117. *Eléments de base des mesures en vol,* by Roger Beteille.

*

1934-1954 : Il Reparto Alta Velocità, Italian commemorative booklet to mark the twentieth anniversary of Francesco Agello's record flight of 1934, with a foreword by General A. Urbani. — Turin, 1954.

These Fuelish Things. — By Bernard Hollowood and Wren. Published by Esso Petroleum Company, Ltd., London, 1955.

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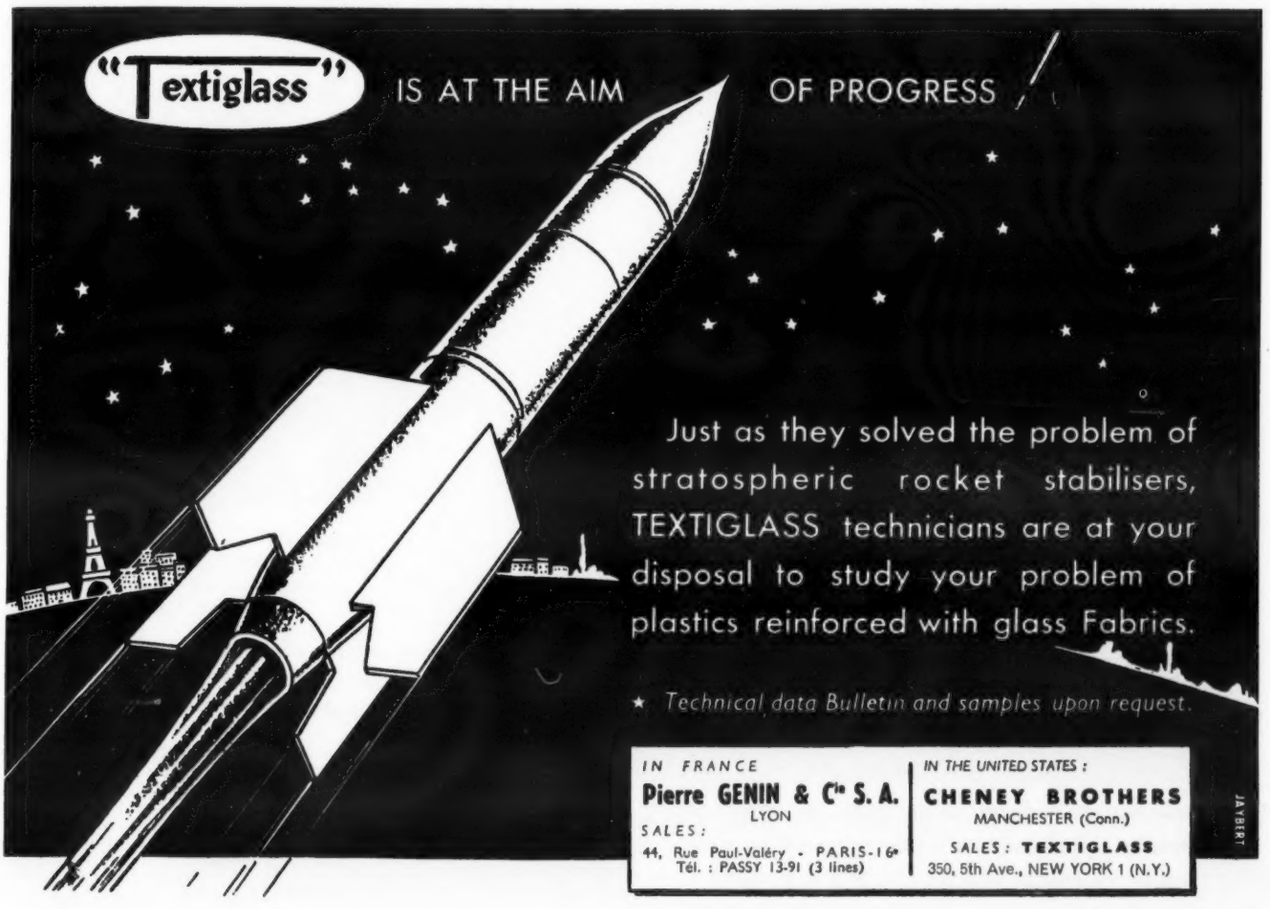
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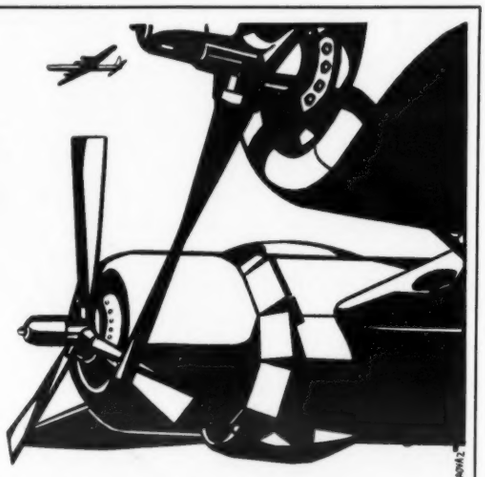

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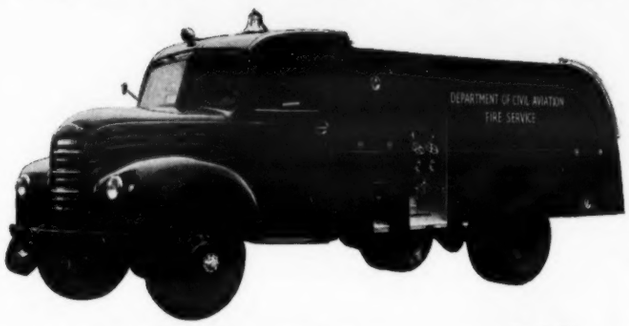

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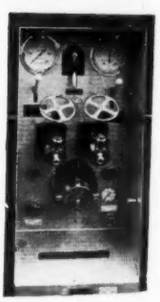

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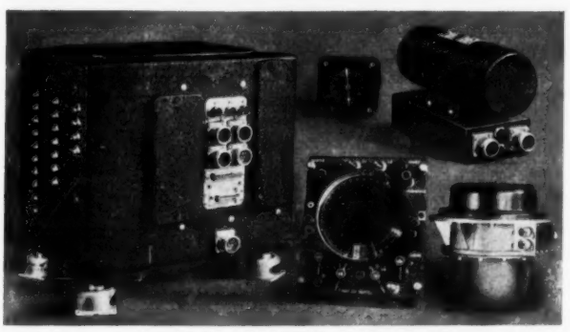

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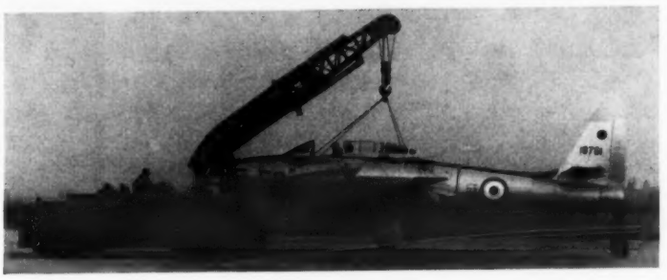

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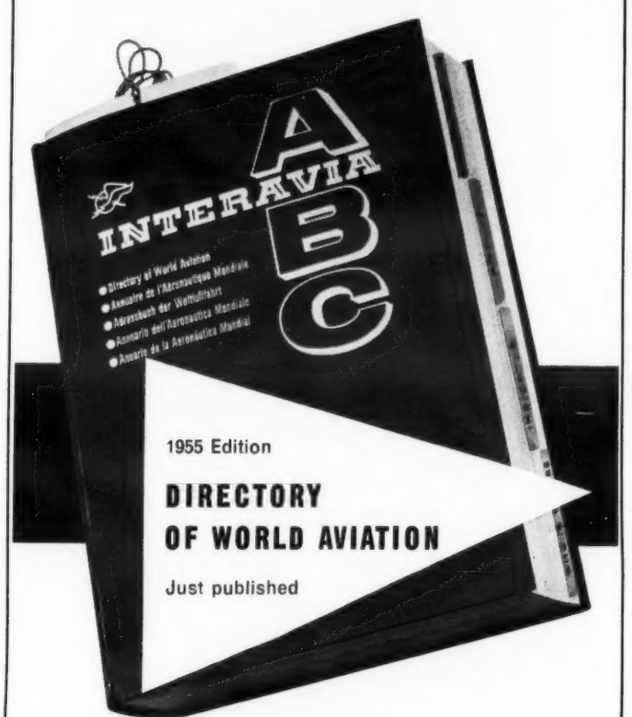

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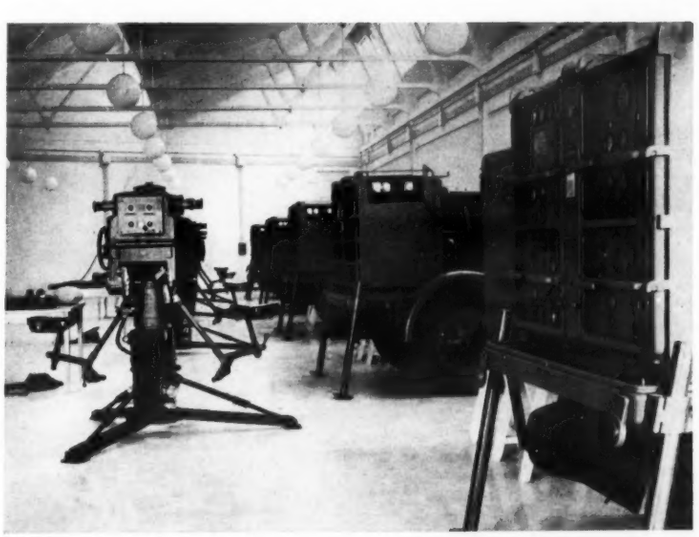

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